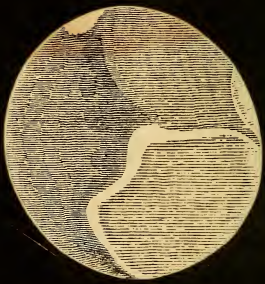
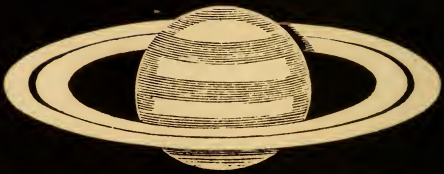
THE LIBRARY OF CONGRESS
1800

MARS.



JUPITER.

SATURN.



# URANOGRAPHY;

OR,

## A DESCRIPTION OF THE HEAVENS;

DESIGNED FOR

## ACADEMIES AND SCHOOLS;

ACCOMPANIED BY

## AN ATLAS OF THE HEAVENS,

SHOWING THE PLACES OF THE PRINCIPAL STARS, CLUSTERS, AND NEBULÆ.

BY

E. OTIS KENDALL,

PROFESSOR OF MATHEMATICS AND ASTRONOMY IN THE CENTRAL HIGH SCHOOL OF PHILADELPHIA, AND MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY.

PHILADELPHIA:
PUBLISHED BY E. H. BUTLER & CO.
1850

QB 63
.K33
1850

Entered, according to the Act of Congress, in the year 1844, by
E. H. BUTLER,
in the clerk's office of the District Court of the United States in and for the Eastern District of Pennsylvania.

By Transfer
SEP 3 1909

J. Fagan, Stereotyper.
C. Sherman, Printer.



LR
K33

10844
Withdrawn

TO

ALEXANDER DALLAS BACHE, LL.D.,

SUPERINTENDENT OF THE U. S. COAST SURVEY, AND LATE PRINCIPAL OF THE PHILADELPHIA HIGH SCHOOL,

DISTINGUISHED ALIKE FOR HIS ATTAINMENTS IN SCIENCE, HIS ZEAL IN ITS ENCOURAGEMENT, AND HIS SUCCESSFUL LABOURS IN THE CAUSE OF POPULAR EDUCATION.

THIS WORK

IS, BY PERMISSION, VERY RESPECTFULLY DEDICATED, BY HIS FRIEND AND OBEDIENT SERVANT,

THE AUTHOR.

# PREFACE.

In offering to the public this brief description of the heavens, it has been my aim to make the work as simple and popular as possible. It is, of course, not to be expected that it can present much claim to novelty or originality. I shall be satisfied if the descriptions are true, and easily understood by the younger class of learners. The want of such a treatise has been felt while endeavouring to furnish popular instruction to the pupils of the High-School in this place. The *Atlas of the Starry Heavens*, published in 1839, in German, by J. J. Von Littrow, the distinguished Director of the Vienna Observatory, was used for some time as a basis of a course of oral instruction. The excellence of Littrow's Atlas, and of his method of describing the heavens, induced me to undertake the translation of the entire work. The maps have been re-engraved with English names of the constellations, and with such modifications as my experience had suggested. On comparing, however, Littrow's text with the most recent publications, particularly the *Micrometric Measures* of the celebrated Struve, I found that the progress

of knowledge in the department of double stars has been so rapid of late, that it was necessary to write anew all that part which relates to this important portion of the sidereal heavens. This I have done in conformity with the most recent publications of Struve and Mædler. Another important modification of Littrow's method was required. He refers to another more extensive publication under the title of the "Wonders of the Heavens." I have extended this description of the heavens so as to embrace a portion of the interesting subjects treated of in that work. In doing so, I have written anew the chapters on the general description of the nebulæ, and clusters of stars, chiefly from English authorities, among whom I mention with pleasure the papers of the elder and younger Herschel;—the popular treatise of the latter, on astronomy, and Madam Somerville's work on the "Connexion of the Physical Sciences." In writing a treatise on Uranography, aiming to be simple and popular, I have thought it necessary to furnish, in each constellation, a method of finding the principal stars in the heavens by the process of *lining*. In these descriptions no novelty could be expected, and no other merit than that of simplicity has been aimed at. The position of the stars in the figures is adapted to this Atlas. The figures do not in all instances occupy the same place and size among the stars as in other Atlases and Globes. They rest, however, on the authority of the celebrated German astronomer Littrow. One important advantage will be found in this Atlas over most others; the

faint outlines only of the figures are given, and the boundaries of the constellations. On a first glance at the maps, the stars are the prominent objects which strike the eye, and the pupil is not distracted in his efforts to learn the constellations, by missing in the heavens the objects made too conspicuous on the map. The number of the maps is so full that there is little distortion of the relative positions of the stars. It may seem almost preposterous in a work which attempts to give an epitome of the sublime discoveries of the Herschels and of Struve, that the fabulous history of the almost useless figures in the constellations should be interwoven; they form, however, a part of the history of the progress of the human mind in one of its noblest studies, and as such must ever claim a place in a popular treatise like the present. While aiming to insert all that is requisite to aid the steps of the *beginner* in astronomy, the claims and wants of the *amateur* have not been quite neglected. The text, in finer print, contains a selection of the most important and interesting double and multiple stars, nebulæ and clusters, in each constellation, so described that any person having a telescope may select as types some which are suited to its capacity, and those who have no instrument may be furnished at once with such a description as the best instruments afford.

The work is simply descriptive of the heavens: to have attempted a treatise on practical astronomy, or the use of instruments, would have made the work too complex and voluminous. Those who wish to culti-

vate the study of *practical* astronomy may avail themselves of Gummere's Astronomy, (edition of 1842), Mason's Supplement to Olmsted's Astronomy, and Bowditch's Practical Navigator. Those who are not possessed of the British Nautical Almanac, will find a valuable auxiliary in Downes' United States Almanac or Complete Ephemeris, which contains numerous examples of useful computations in practical astronomy.

PHILADELPHIA, *April* 23, 1844.

# TABLE OF CONTENTS.

## PART I.

### Sec. 1. — General Description of the Heavens.


Page

Appearance of the Starry Heavens ..... 11
Horizon, Zenith, Meridian..... 12
North Pole, Circumpolar Stars, Pole Star ..... 13
Diurnal motion of the Heavens, Celestial Sphere ..... 13


### Sec. 2. — Preliminary Definitions.


Axis of the Heavens, Celestial Equator, Geometric Poles.. 14
Division of the Circle..... 14
Declination Circle, Vertical Line, Zenith and Nadir .... 15
Meridian of a place, Vertical Circle, Ecliptic..... 15
Equinoxes, Equinoctial Colure, Right Ascension..... 16
Declination ..... 16


### Sec. 3. — Constellations.


Origin of Constellations—their antiquity ..... 17
Geography, Uranography ..... 17
Littrow's Figures, Bayer's Designation of the Stars .... 18
Changes in their Magnitudes ..... 19


### Sec. 4. — Magnitudes of the Stars.


Division of Stars into Magnitudes ..... 19
Herschel's Classification, Struve's do..... 20

SEC. 5. — A MORE PARTICULAR DESCRIPTION OF THE STARRY HEAVENS.

Brilliancy of the Stars, Twinkling..... 20
Planets. Fixed Stars—their number ..... 21
Description of Uranography ..... 22
Use of a Celestial Atlas ..... .. 22
Comparative Brilliancy of Stars of different Magnitudes. 23
Bode's Distribution of Stars..... 23
Harding's Atlas. Number of Telescopic Stars..... 24
Their tendency to appear in Groups..... 25

SEC. 6. — DOUBLE AND MULTIPLE STARS.

Tendency of Stars to appear in Pairs ..... 25
Mitchel's and Herschel's Opinions of Double Stars..... 26
Herschel's Discoveries, Argelander's Investigations..... 26
Authors of Works on Double Stars ..... 26
Herschel's Method of Computing their Orbits ..... 27
Encke's Method, Mædler's Labours ..... 27
Number of Double Stars—Physical Connexion..... 27
Ternary, Binary, Multiple Stars, &c..... 27
Stars Optically Double or Multiple ..... 28
Revolutions of the Double Stars ..... 28
Prevalence of Newtonian Gravity..... 28
Solar and Stellar Systems compared ..... 28
Number of Double Stars above the 8th Magnitude ..... 29
Struve's Number of Stellar Systems ..... 29
Mædler's recent Estimate ..... 30

SEC. 7. — COMETS.

Reference to Section 22 ..... ..... 30

SEC. 8. — VARIABLE STARS.

Definition, Catalogue, Mira Ceti ..... 31
Algol, and other Variable Stars ..... 32
General Remarks, Causes of their Variations..... 34
New and Lost Stars ..... ... 35

## Sec. 9. — Nebulæ and Clusters of Stars.

Remarkable Groups, Milky-Way ..... 36
Its Nature and Formation ..... 37
Supposed Position of the Sun in the Milky-Way ..... 38
Resolvable Nebulæ, Globular Clusters ..... 39
Irresolvable Nebulæ, Annular do ..... 40
Planetary and Stellar Nebulæ, Nebulous Stars ..... 41
Zodiacal Light supposed to be a Nebulosity ..... 42
Clusters of Nebulæ ..... 42
Double Nebulæ, Number of Nebulæ ..... 43
Their supposed Origin ..... 43
General Remarks ..... 44

## Sec. 10. — Description of the Maps.

Maps of the Northern and Southern Hemispheres ..... 45
Explanations of the Maps ..... 46
Maps of the Northern Hemisphere, Plates III. to VII. ... 46
Maps of the Equatorial Regions, Plates VIII. and IX. ... 46
Maps of the Southern Hemisphere, Plates X. to XIV. ... 46
Map for Lining, Plate XV ..... 47

## Sec. 11.—Description of the Constellations.

### Plate I. — Northern Hemisphere.

### Plate II. — Southern Hemisphere.

### Plate III.—Constellations.

Ursa Minor—*The Little Bear* ..... 47
Cepheus—*The King* ..... 48
Draco—*The Dragon* ..... 49
Lacerta—*The Lizard* ..... 51
Honores Frederici—*Frederick's Honours* ..... 52
Canes Venatici—*The Grey-Hounds* ..... 52
Quadrans Muralis—*The Mural Quadrant* ..... 52
Cygnus—*The Swan* ..... 53

PLATE IV. — CONSTELLATIONS.

Ursa Major—*The Great Bear* ..... 57
Custos Messium—*The Guardian of the Harvest* ..... 59
Camelopardalis—*The Giraffe* ..... 59
Cassiopeiæ—*The Lady in her Chair* ..... 60
Leo Minor—*The Little Lion* ..... 62
Lynx—*The Lynx* ..... 62
Perseus et Caput Medusæ—*Perseus and Medusa's Head* .. 63
Tarandus—*The Reindeer* ..... 65
Telescopium Herschelii—*Herschel's Telescope* ..... 65

PLATE V. — CONSTELLATIONS.

Pegasus—*The Flying Horse* ..... 66
Andromeda—*Andromeda* ..... 68
Triangula—*The Triangles* ..... 69
Musca—*The Fly* ..... 70
Pisces—*The Fishes* ..... 70
Aries—*The Ram* ..... 71

PLATE VI. — CONSTELLATIONS.

Auriga—*The Charioteer* ..... 73
Taurus—*The Bull* ..... 74
Cancer—*The Crab* ..... 76
Orion—*Orion* ..... 78
Gemini—*The Twins* ..... 81
Monoceros—*The Unicorn* ..... 82
Canis Minor—*The Little Dog* ..... 83

PLATE VII. — CONSTELLATIONS.

Boötes—*The Herdsman* ..... 84
Lyra—*The Harp* ..... 86
Hercules—*Hercules* ..... 88
Corona Borealis—*The Northern Crown* ..... 90
Taurus Poniatowski—*The Polish Bull* ..... 91
Leo Major—*The Great Lion* ..... 92

PLATE VIII. — CONSTELLATIONS.

Virgo—*The Virgin* ..... 94
Coma Berenices—*Berenice's Hair* ..... 100
Sextans—*The Sextant* ..... 102

PLATE IX. — CONSTELLATIONS.

Antinoüs—*Antinoüs* ..... 103
Aquila—*The Eagle* ..... 103
Libra—*The Scales* ..... 104
Serpentarius vel Ophiuchus—*The Serpent-bearer* ..... 105
Serpens—*The Serpent* ..... 108
Delphinus—*The Dolphin* ..... 109
Equüleus—*The Little Horse* ..... 110
Scutum Sobieski—*Sobieski's Shield* ..... 110
Turdus Solitarius—*The Solitary Thrush* ..... 111
Vulpecula et Anser—*The Fox and Goose* ..... 111
Sagitta—*The Arrow* ..... 112

PLATE X. — CONSTELLATIONS.

Sagittarius—*The Archer* ..... 113
Scorpio—*The Scorpion* ..... 114
Lupus—*The Wolf* ..... 115
Ara—*The Altar* ..... 116
Norma, vel Quadra Euclidis—*The Rule* ..... 116
Telescopium—*The Telescope* ..... 116
Corona Australis—*The Southern Crown* ..... 116

PLATE XI. — CONSTELLATIONS.

Aquarius—*The Water-bearer* ..... 117
Capricornus—*The Goat* ..... 119
Piscis Australis—*The Southern Fish* ..... 121
Globus Ærostaticus—*The Balloon* ..... 121
Microscopium—*The Microscope* ..... 121
Grus—*The Crane* ..... 121
Phœnix—*The Arabian Bird* ..... 121
Apparatus Sculptoris—*The Sculptor's Tools* ..... 121
Indus—*The Indian* ..... 122

PLATE XII. — CONSTELLATIONS.

Cetus—*The Whale* ..... 123
Eridanus—*The River Po* ..... 124
Lepus—*The Hare* ..... 125
Harpa Georgii—*George's Harp* ..... 125
Sceptrum Brandenburgium—*Sceptre of Brandenburgh* .. 126
Apparatus Chemicus—*Chemical Apparatus* ..... 126
Machina Electrica—*Electrical Machine* ..... 126
Cæla Sculptoris—*The Graver* ..... 126
Horologium—*The Clock* ..... 127

PLATE XIII. — CONSTELLATIONS.

Canis Major—*The Great Dog* ..... 127
Argo Navis—*The Ship Argo* ..... 129
Columba—*The Dove* ..... 130
Felis—*The Cat* ..... 130
Equüleus Pictoris—*The Painter's Easel* ..... 130
Officina Typographica—*The Printing Press* ..... 131
Pyxis Nautica—*The Mariner's Compass* ..... 131

PLATE XIV. — CONSTELLATIONS.

Hydra—*The Water-Serpent* ..... 131
Crater—*The Cup* ..... 133
Centaurus—*The Centaur* ..... 133
Corvus—*The Crow* ..... 134
Antlia Pneumatica—*The Air Pump* ..... 135
Robur Caroli—*Charles' Oak* ..... 135
Crux—*The Cross* ..... 135

SEC. 12. — THE CALENDAR OF STARS.

January ..... 137
February ..... 140
March ..... 143
April ..... 146
May ..... 148
June ..... 150

July ..... 153
August ..... 156
September ..... 159
October ..... 162
November ..... 164
December ..... 166

Sec. 13.

Telescopic appearance of Double Stars ..... 169

Sec. 14.

Portions of the Heavens rich in Stars ..... 170

Sec. 15.

Clusters of Stars ..... 172
Stellar Nebulæ ..... 174
Double Nebulæ ..... 177
Hollow Nebulæ ..... 178
Irresolvable and Planetary Nebulæ ..... 179
Other remarkable Nebulæ ..... 182

## PART II.

Sec. 1.

General Description of the Solar System ..... 185

Sec. 2.

Ptolemaic System ..... 186

Sec. 3.

Copernican System ..... 187
Ancient Opinion regarding the Figure of the Earth ..... 188
Rotundity of the Earth demonstrated ..... 188
Proof of the Earth's Diurnal Revolution ..... 189

## Sec. 4.

Definitions..... 190

## Sec. 5.

Kepler's First Law ..... 195
Definitions of the Ellipse ..... 195
Kepler's Second Law ..... 196
Illustration of Orbital Motion..... 197
Kepler's Third Law..... 197

## Sec. 6.

Newtonian Theory of Gravitation ..... 198
Principle of Gravitation ..... 199
Extension of the Law of Gravity to the Stars ..... 200

## Sec. 7.

The Sun..... 201
Figure of the Sun..... 202
Diameter and Revolution on its Axis..... 202
Opinions concerning the Nature of the Sun..... 203
Zodiacal Light—its Phenomena ..... 203
Force of Gravity at the Surface of the Sun..... 204
Proper Motion of the Sun ..... 205

## Sec. 8.

Mercury—Rotation upon his Axis—his Distance ..... 206
His Diameter ..... 207
Distinction between *Inferior* and *Superior* Planets..... 207
Greatest Elongation of Mercury..... 207
Transits of Mercury..... 208
Density of Mercury ..... 209
Force of Gravity at its Surface..... 210
Ancient Names of this Planet..... 210

## Sec. 9.

Venus—its Distance, Rotation and Magnitude ..... 211
Brilliancy of Venus ..... 211

Great Vicissitudes of its Seasons..... 212
Transits of Venus ..... 213
Sun's Parallax as deduced from these Transits..... 214
Effects of the small Eccentricity of its Orbit ..... 214
Various Names of Venus ..... 215

## Sec. 10.

The Earth—its Distance from the Sun, and Diameter.. 215
Its Mass, Density and Figure..... 216
The Motions of the Earth..... 217
Day and Night..... 218
The Seasons ..... 220
The Earth's Satellite ..... 222
The Atmosphere..... 222
Cause of Winds..... 224
Change of Position of the Earth's Axis in the Heavens 225
Polar Stars ..... 225
Second Variation in the Position of the Earth's Orbit.. 227
Definition of Perturbation..... 227
Third Variation of the Position of the Earth's Perihelion 227
Mythological Names of the Earth ..... 228

## Sec. 11.

General Remarks concerning Secondary Planets ..... 228
Points of Resemblance with their Primaries..... 229
Equality of their Periods of Revolution and Rotation .. 230
Appearances of the Primary Planet viewed from its Secondaries ..... 231
Force of Gravity upon the Secondary Planets ..... 232

## Sec. 12.

The Moon..... 232
Its Revolution, Diameter, and apparent Motion..... 233
Libration in Longitude and Latitude ..... 234
Phases of the Moon..... 235
Eclipses—Harvest Moon..... 237

Appearances of the Heavens as seen from the Moon... 238
Eclipses at the Earth and at the Moon compared..... 240
Description of the Moon's Surface..... 241
Lunar Caverns—Crater-formed Elevations ..... 242
Lunar Volcanoes—Central Mountains..... 243
Heights of Lunar Mountains ..... 244

SEC. 13.

Mars—its Distance from the Sun—Diameter, &c..... 245
Inequality in the length of its Seasons ..... 247
Its Days also unequal..... 248
Transits of inferior Planets seen from Mars..... 248
Mythological Names of this Planet..... 249

SEC. 14.

Vesta—its Diameter—Distance from the Sun, &c..... 250
Its Mythological History..... 250

SEC. 15.

Juno—its Place in the System, and its Orbit..... 251
Number of its Names among the Ancients..... 251

SEC. 16.

Ceres—its Description and Mythology ..... 252

SEC. 17.

Pallas—its Place in the System..... 252
The great Inclination of its Orbit—its ancient History.. 253

SEC. 18.

General Remarks concerning the Asteroids..... 253
Their Periods of Revolution ..... 255
Force of Gravity at their Surfaces very small ..... 256

SEC. 19.

Jupiter—its Diameter, Period of Revolution, &c..... 257
Effects of the great centrifugal Force at its Equator.... 258

Difference of the Seasons and of the length of Days... 258
Intensity of Light and Heat ..... 259
Brightness of Jupiter ..... 259
Telescopic Appearance..... 259
Jupiter's Satellites ..... 261
Their Diameters ..... 261
Apparent Motions of these Satellites ..... 262
Their combined Light not equal to that of the Moon... 263
Mythological History of Jupiter..... 264

## Sec. 20.

Saturn—its Distance from the Sun, Diameter, &c..... 265
Dimensions of its Rings ..... 266
Telescopic appearance of the Planet ..... 266
Rotation of the Rings ..... 267
Cause of their elliptical Appearance ..... 267
The Rings must be *irregular* Solids ..... 268
Appearance of the Rings from the Planet itself ..... 269
Force of Gravity at the Surface of Saturn..... 270
Satellites of this Planet..... 271
Their Phases ..... 271
Their Eclipses ..... 272
Their Periods of Revolution..... 273
The Mythology of Saturn..... 274

## Sec. 21.

Herschel, or Uranus..... 275
Its Appearance to the unassisted Eye ..... 275
Its mean Distance from the Sun—its Diameter, &c.... 275
The apparent Diameter of the Sun as seen from Uranus. 276
Amount of the Annual Parallax of the Fixed Stars for Uranus..... 277
Peculiarity of the Uranian System regarding the Satellites ..... 277
Phases of the Satellites..... ..... 277
Their Eclipses ..... 278

Density of Uranus ..... 278
Distances and Periods of Revolution of the Satellites .. 278
Mythological Account of Uranus ..... 279

## Sec. 22.

Comets—Origin of their Name ..... 280
Number of Comets ..... 280
Heads of Comets ..... 281
Their nebulous Envelopes ..... 282
The Tail of Comets ..... 282
Apparent Lengths as seen from the Earth ..... 283
Estimated real Lengths ..... 284
Origin of the Envelope and Tail ..... 284
Dissipation of the Substance of Comets ..... 286
Popular Superstitions respecting Comets ..... 286
Elements of the Orbits of Comets ..... 288
Average Inclination of their Orbits ..... 288
Probability that Comets move in Ellipses ..... 289
Periodical Comets ..... 290
Halley's Comet—its supposed Appearances ..... 291
Its certain Appearances ..... 292
Olbers' Comet—when discovered, &c ..... 293
Encke's Comet—its observed Returns ..... 294
Proof of a resisting Medium obtained by means of this Comet ..... 295
Gambart's Comet ..... 296
Cause of its invisibility in 1839 ..... 296
Comets supposed to be periodical ..... 297
Third Comet of 1843 ..... 298
Peculiarities of this Comet ..... 299
Instability of the Position of its Orbit ..... 300

## Sec. 23.

Eclipses of the Moon—their Cause ..... 301
Partial, total and central Eclipses ..... 301
The Shadow of the Earth ..... 302

Duration of a Lunar Eclipse..... 302
Description of the Plate, Fig. 1..... 302
Difficulty of observing with exactness a Lunar Eclipse. 304
Eclipses of the Sun—how caused ..... 305
Description of the Plate, Fig. 2..... 305
Central, total and partial Eclipses ..... 305
Annular Eclipses ..... 306
Number of Eclipses in a Year ..... 307

## Sec. 24. — Tides.

High and low Tides—Spring Tides..... 308
Neap Tides..... 309
Tide Wave ..... 310
Causes of the Neap Tides ..... 312
Heights of Tides in various Places ..... 315
Co-tidal Lines—Unit of Altitude..... 316
Establishment of a Port—Atmospheric Tides ..... 317

## Appendix.

Elements of the Orbits of Binary Stars ..... 319
List of Stars which, from their *Relative Motion*, are supposed to form Stellar Systems..... 320
List of Stars supposed from their *Proper Motion* to form Stellar Systems..... 323
Elements of the Orbits of the Planets ..... 324

## DIRECTIONS TO THE BINDER.


| | | |
|---|---|---|
| Mars, Jupiter, and Saturn | Frontispiece. | |
| Gamma Virginis | to face page | 96 |
| p of the Serpent Bearer | " | 106 |
| Phases of Venus | " | 212 |
| Seasons | " | 221 |
| Phases of the Moon | " | 235 |
| Phases of Saturn | " | 267 |
| Great Comet of 1811 and 1819 | " | 286 |
| Great Comet of 1843 | " | 298 |

# PART I.

## SEC. 1.

### GENERAL DESCRIPTION OF THE HEAVENS.

THE starry heavens, on a clear evening, present to an observer the appearance of the hollow surface of a vast hemisphere, in the centre of which he is placed, and which is bounded by the seemingly circular plane on which he stands. This plane appears to meet the heavens in a distant circular line which is called the *horizon*. In this hollow surface we see the sun by day, the moon sometimes by day, sometimes by night, and the planets, stars and comets, by night only. A slight degree of observation will show that all these objects partake of a common apparent motion from east to west.

If we turn towards the south, we may observe some star rising a little to the east of south; and if we watch its course, we shall find that it ascends for a time until it has reached a point towards the south at a little distance above the horizon, and then descends gradually till it sets in the west,—the points of the horizon at which it rises

and sets, being equally distant from the southern point. If we observe, in the same manner, a star which rises farther from the southern point than the preceding, we shall find that it follows a similar path, except that it attains to a greater height and continues longer visible. The arc or path in which it appears to move, is parallel to that of the former, but larger. A circle drawn from the south point, perpendicular to the horizon, will *bisect* or divide into two equal portions all the arcs described by the stars, while above the horizon it will pass through the point directly over head, called the *Zenith*, and continuing downwards, will cut the horizon in the north point. This circle is called the *Meridian*. It corresponds to the geographical meridian prolonged in every direction to the stars. If we continue our observations upon the stars as they rise at different points of the eastern portion of the horizon, we soon discover that the paths they describe are all parallel to each other and bisected by the meridian,—that the segment or visible portion of the circle described by any one star, is greater in proportion to its distance from the south point, at the moment of rising,—that a star which rises near the north point of the horizon, will describe nearly an entire circle above the horizon,—and finally, that there are many stars above the northern portion of the horizon which never set, but which, if followed with the eye for a number of hours, will be found to describe concentric circles

that lie wholly above the horizon; near the centre of these circles is a star which appears to remain stationary. This is called the *Pole Star.* And all the stars which do not set are called *Circumpolar Stars.* When the pole star is more accurately observed with instruments, it is found to describe a small circle around a point, at a distance of about a degree and a half. This point is called the *North Pole of the heavens,* or simply the *North Pole.*

If these observations be continued on several successive evenings, it will be found that the same stars always rise at the same points, and move precisely in the same manner from east to west; and that at a given time on any two successive evenings, they appear to occupy nearly the same positions with reference to the earth, and exactly the same positions with reference to each other.

The appearance of the heavens, therefore, to an observer, supposing himself stationary, is that of an immense concave sphere, of which he occupies the centre, and which revolves, once in about twenty-four hours, round an axis, inclined to the horizon, one extremity of which axis is the north pole. This motion is called the *diurnal motion of the heavens.* The stars appear to be all fixed upon the surface of this *Celestial Sphere;* while the sun, moon, planets and comets, describe different paths over the surface and among the stars. The apparent diurnal motion of the heavenly bodies is the same as it would be if they were sta-

tionary, while the earth, situated at the centre of the celestial sphere, revolves from west to east once in twenty-four hours, about an axis which produced would pierce the heavens at the north pole.

---

## SEC. 2.

### PRELIMINARY DEFINITIONS.

THE *Axis of the Heavens* is the line about which the heavens appear to revolve. It passes through the centre and axis of the earth. The points in which it pierces the heavens are called the *North* and *South Poles*.

The *Celestial Equator*, or simply the *Equator*, is the great circle in which the plane of the earth's equator produced would cut the celestial sphere. It intersects the horizon at the *east* and *west* points.

The poles of the heavens are the *Geometric Poles* of the equator. Any circle whose centre is the centre of the sphere, and whose diameter is a diameter of the sphere, is called a *Great Circle*. The poles of any circle are the extremities of that diameter of the sphere which is perpendicular to the plane of the circle, or they are points on the surface of the sphere equally distant from all points in the circumference of the circle. The poles of a great circle are at the distance of a quadrant or 90° from all points in the circumference of that circle.

Every circle is considered as divided into 360 equal parts, called *degrees;* each degree into 60 equal parts, called *minutes;* and each minute into

60 equal parts, called *seconds*. They are marked ° ′ ″ — thus: 10° 2′ 20″ — which is read ten degrees, two minutes, and twenty seconds.

The *Declination Circle* of a star is a great circle passing through the poles of the heavens and the star, and cutting the equator at right angles These circles are sometimes called *Meridians*. They are analogous to meridians of places on the earth's surface.

*Parallels of Declination* are small circles parallel to the equator.

A *Vertical Line*, at any place, is the direction assumed by the plumb-line at that place.

The *Zenith* and *Nadir*, at any place, are the points above and below the horizon in which the vertical line produced would pierce the heavens. They are the poles of the horizon.

The *Meridian* of a place is the declination circle passing through the zenith of the place, cutting the horizon at right angles in the *North* and *South* points.

A *Vertical Circle* is a great circle passing through the zenith and nadir, perpendicular to the horizon. The *Prime Vertical* is that vertical circle which is at right angles to the meridian of the place, and cuts the horizon in the east and west points.

The *Ecliptic* is the path through which the sun appears to move annually among the stars from west to east. It is a great circle of the celestial sphere, the plane of which is inclined to that of

the equator in an angle of about $23\frac{1}{2}°$. This angle is called the *Obliquity of the Ecliptic.* The ecliptic cuts the equator in two opposite points, called the *Equinoxes.* The sun passes one of these points about the 21st of March, and the other about the 23d of September; the former is called the *Vernal,* and the latter the *Autumnal Equinox.* The poles of the ecliptic are two opposite points of the celestial sphere, about $23\frac{1}{2}°$ distant from the poles of the heavens.

The *Equinoctial Colure* is the declination circle passing through the equinoxes.

The *Right Ascension* of a heavenly body is the arc of the equator reckoned from the vernal equinox eastward to the declination circle passing through the body. It is precisely analogous to the longitude of a place on the earth's surface; if the position of the equinoctial colure at the moment be taken on the terrestrial meridian from which longitudes are reckoned. Right ascension is sometimes estimated in *time,* allowing fifteen degrees for an hour, fifteen circular minutes for a *minute of time,* &c.

The *declination* of a heavenly body is the arc of a declination circle intercepted between the equator and the centre of the body; or, in other words, it is the distance of the body from the equator. The declination of an object is called *North* or *South,* according to its position north or south of the equator. Objects on the equator have no declination. All objects on the same

parallel of declination have the same declination. The declination of a heavenly body is analogous to the latitude of a place on the earth's surface.

The right ascension and declination of a heavenly body determine its place in the heavens. As these terms occur very frequently, they are generally, for the sake of brevity, designated by R. A. and Dec.

---

## SEC. 3.

### CONSTELLATIONS.

For the sake of convenient reference, the heavens were early divided into *constellations*, to which were assigned, for the most part, names celebrated in fable or in history. The origin of the constellations is of great antiquity. The oldest books that allude to the starry heavens, treat of them as being divided into constellations; the oldest heathen poets, Hesiod and Homer, mention some of them by names that are now familiar; and we find *Orion* and the *Pleiades* spoken of in the book of Job and in the prophecy of Amos.

In the maps of the stars, the dotted boundary line marks the space allotted to each constellation in the heavens, in the same manner as nations and provinces are designated in common geography. Hence works like this are called Geographies of the Heavens, according to popular acceptation. The word *Uranography* is more correct; but is

not much used in popular treatises. The figures in the enclosures for the several constellations, originally designed for Littrow, are not in every instance in the same place as those found on common globes, and other atlases of the heavens. To avoid confusion in this respect, the descriptions of the position of the stars in the figures, are adapted to the maps in this book, which rest on the authority of this celebrated German astronomer.

The stars in each constellation are distinguished by the letters of the Greek alphabet, which are applied to them in the order of their relative brightness; the principal or brightest star being called $\alpha$, the next $\beta$, &c. In the larger constellations, after exhausting the Greek alphabet, the Roman letters are used, and sometimes numbers. Thus: $\alpha$ Lyræ denotes the brightest star in the constellation of the *Lyre*, $\alpha$ Tauri the brightest star in the Bull, &c. Many of the principal stars are also known by particular names, as: *Sirius* or the *Dog Star*, $\alpha$ of the Great Dog; *Aldebaran* or the *Bull's Eye*, $\alpha$ Tauri; *Regulus* or the *Lion's Heart*, $\alpha$ Leonis, &c.

To facilitate the studies of those readers who are not familiar with Greek, we here insert the alphabet of that language:

| | |
|---|---|
| Alpha, .... $\alpha$ ... a | Epsilon, ... $\varepsilon$ ... e short. |
| Beta, ..... $\beta$ ... b | Zeta, ..... $\zeta$ ... z |
| Gamma, ... $\gamma$ ... g | Eta, ..... $\eta$ ... e long. |
| Delta, ..... $\delta$ ... d | Theta, .... $\theta$,$\vartheta$ .. th |

| | | | |
|---|---|---|---|
| Iota, ..... | ι ... i | Rho, ..... | ρ ... r |
| Kappa, ... | κ ... k c | Sigma, ... | σ ... s |
| Lambda, .. | λ ... l | Tau, ..... | τ ... t |
| Mu, ..... | μ ... m | Upsilon, .. | υ ... u |
| Nu, ..... | ν ... n | Phi, ..... | φ ... ph |
| Xi, ..... | ξ ... x | Chi, ..... | χ ... ch |
| Omicron, .. | o ... o short. | Psi, ..... | ψ ... ps |
| Pi, ..... | π ... p | Omega, .. | ω, ϖ .. o long. |

These Greek letters were assigned to the stars by Bayer in the beginning of the seventeenth century. They do not conform in all instances with the recent classification of the stars in the order of brightness by Sir John Herschel. This circumstance shows that a change has taken place in the relative brightness of the stars since Bayer's time. To avoid confusion, Bayer's Greek letters are still used.

---

## SEC. 4.

### MAGNITUDES OF THE STARS.

THE stars are also divided into different orders or classes, called *Magnitudes,* according to their relative brilliancy: the brightest stars being said to be of the *first magnitude;* those a little less brilliant, of the *second;* and thus the distinction is continued to the *sixth magnitude,* which includes the smallest stars generally visible to the naked eye. The classification is still extended to the telescopic stars, commencing with those of the seventh magnitude, which are readily seen in a good opera glass, and embracing the smallest stars visible in the most powerful telescopes formerly used.

Sir John Herschel uses 14 classes of telescopic stars, his smallest being of the 20th magnitude. Struve divides them into 6 classes, his smallest being of the 12th magnitude, the same as the 20th of Herschel. Struve follows the analogy of the first 6 classes: his 7th class appears in the fourteen feet Fraunhofer Telescope, at Dorpat in Russia, as bright as a star of the first magnitude to the naked eye. His 12th or Herschel's 20th magnitude appears, in such an instrument, as faint as a star of the 6th magnitude to the naked eye. Struve's magnitudes are used in this book. They may be adapted to Herschel's scale by means of the following table:

| Struve's Classes. | Corresponding Classes of Herschel. |
|---|---|
| 1st to 6th | 1st to 6th |
| " 7th | 7th and 8th |
| " 8th | 9th and 10th |
| " 9th | 11th and 12th |
| " 10th | 13th and 14th |
| " 11th | 15th, 16th and 17th |
| " 12th | 18th, 19th and 20th |

## SEC. 5.

### A MORE PARTICULAR DESCRIPTION OF THE STARRY HEAVENS.

If we examine the heavens on a clear evening, we find the celestial vault crowded with a vast number of stars of various degrees of brilliancy. Some are so bright that the eye cannot gaze on them steadily. The effect of this dazzling light on the nerves of the eye is such as to cause an apparently tremulous motion of the stars themselves,

and they are said to *twinkle*. This serves to distinguish these bright stars from another class of bodies, of which only one or two are usually visible at the same time in the heavens. These, though nearly or quite as large as the brightest stars, have a softer light, which we are enabled to gaze on steadily, and which therefore are said not to twinkle. These latter are also found to wander about among the other stars, and are therefore called *planets*, or *wanderers*, from a Greek word of that signification. The twinkling stars, on the contrary, compose groups that always maintain nearly the same relative position towards each other, and are hence called *fixed* stars. The fixed stars are divided into six classes, according to their degrees of brilliancy. The sixth class contains the smallest stars which on a clear night can be seen with a good eye without the assistance of a spy-glass or telescope. The number of these fixed stars seems at a casual glance to be countless, and they are said in common language to be "as numerous as the leaves on the trees, or the sands on the sea-shore." The attempt of an ancient astronomer to count the fixed stars, and thus to assign a limit to their number, was supposed to savour of impiety. A more attentive examination of any single group dispels this popular illusion, and its numbers are found to be readily ascertained. In this way, by counting the stars in the several groups that may be seen above and around us at once, we find that their

actual number is less than 2000. Since we see less than half of the stars in the concave surface of the heavens at once, we might suppose that the number of stars in these six classes is not much above 4000. In fact, these six classes comprise in all only about 3800 stars in the northern, and fewer in the southern hemisphere, so that they may all be counted in a few hours. The illusion produced by a hasty glance is easily explained. Each bright star leaves an impression on the eye for some moments, and thus by looking around the number of impressions is indefinitely increased. Not only have all the stars visible to the naked eye been counted and classified, but the peculiar characteristics of each have been examined with the most powerful telescopes, and recorded with as much care and attention as those of the principal cities of the earth in our geographies. Uranography, or a description of the various bodies in the starry *heavens*, has now become a part of a polite education, as much as geography or a description of the places on the *earth* is of a useful one. In both, the aids to a course of study are the same. A *uranography* and *celestial atlas* or map of the heavens are required for obtaining a knowledge of the stars. A *geography* and *atlas* or map of the earth are necessary to obtain a knowledge of the globe which we inhabit.

Besides the six or seven thousand stars of the first six magnitudes, a really countless number has been revealed to us by the telescope. If we

take for the seventh class of stars those which in the largest telescopes appear as bright as stars of the first magnitude to the naked eye, and continue with the telescopic stars the analogy with the first six classes, we shall have for the 12th class the smallest stars visible in any telescope, or those which in the largest telescopes appear as bright as stars of the sixth magnitude to the naked eye.

By comparison of the brilliancy of the different classes or magnitudes of stars, it is found that if sixty-two of the smallest stars visible to the naked eye (class sixth) were grouped together so closely as to seem like one star, the brightness of the group would be equal to that of a star of the first magnitude; and 100,000 of those of the 12th magnitude would be required to produce the same degree of brilliancy when similarly grouped.

If all the stars were of the same size and brilliancy, those of the sixth magnitude should be about eight times, and those of the twelfth magnitude about 300 times as remote from us as the stars of the first magnitude. If the stars, besides being *uniform* in *size* and *brilliancy*, were also distributed at *uniform distances* in space, we might form some conclusion respecting their number in each of the twelve classes. Now, according to Bode's Uranographia, the stars of the first four classes are thus proportionally distributed:

18 of the 1st class, or magnitude.
52 " 2d " "

177 of the 3d class, or magnitude.
376 " 4th " "

If we suppose that Harding's Atlas of the Stars contains about three-fourths of the whole surface of the heavens, we shall have for the next two classes the following numbers.

1000 of the 5th class, or magnitude.
4000 " 6th " "

According to this law of increase, we might expect to find among the telescopic stars

| | | |
|---|---|---|
| 26,000 | of the | 7th magnitude. |
| 170,000 | " | 8th " |
| 1,100,000 | " | 9th " |
| 7,000,000 | " | 10th " |
| 46,000,000 | " | 11th " |
| 300,000,000 | " | 12th " |

If actual observation should confirm this estimate, we should be led to believe that something like a uniformity or average value prevails in the real size and brilliancy of the stars, and in their real distance from each other. Now the recent examination of the stars in the northern hemisphere by Struve with the Pulkovah refractor, shows that there are 12,800 stars of the 7th magnitude in the northern hemisphere, which is about half the above estimate for both hemispheres. Again, from the same astronomer's observations at Dorpat, it appears that there are not less than 120,000 stars of the first eight classes between the north pole and the fifteenth parallel of south declination. This would leave for the 8th class in the whole sphere a number conforming pretty well with the above estimate. It seems natural then to suppose that such a law prevails. From this examination we may conclude that a telescope still more powerful than the Dorpat refractor, perhaps the twenty-three feet refractor at Pulkovah, which might reveal to us another or *thirteenth* class of stars, would exhibit some *two billions* more.

In this manner we may stretch the imagination

beyond all bounds, and confirm the remark of the ancient sage, though on very different grounds, that the number of stars in the heavens, as well as the distance of the remotest, is really without limit.

Not only do we notice in the heavens this distribution of the stars into the classes already enumerated, but we are also struck with their tendency to present themselves in groups. These particular groups or constellations have in all ages, and among all nations, received certain popular names from a fancied resemblance to natural objects.

This tendency of the stars to the formation of groups in the heavens, is too remarkable to be the result of accidental distribution in space; but it is impossible for us to perceive the immediate cause of such a distribution.

---

## SEC. 6.

### OF THE DOUBLE AND MULTIPLE STARS.

The same tendency to the formation of groups of stars, which is noticed in a casual glance at the heavens, is more remarkably displayed on a close examination with the aid of the telescope. Pairs and multiples of stars so close to each other as only to be seen separately in the most powerful telescopes, are found in great numbers. These

pairs and groups have been noticed since the first invention of the telescope. But it is only recently that they have received from astronomers that care and attention which their importance demands.

In 1767, Mr. John Mitchel expressed a belief that these double stars have some peculiar physical connexion with each other, and invited astronomers to watch them, and ascertain whether the one is not a satellite revolving round the other. It does not appear that much notice was taken of this theory. In 1780, the elder Herschel commenced the observation of these double stars, in order to determine their parallax and distance from the sun, by the yearly changes in their distance and bearing from each other. He soon found that these changes could not be accounted for by the change of place of the observer on the earth, in her annual motion round the sun. He then attempted to explain them by supposing a motion of our sun and system of planets in space. This brilliant discovery of the motion of our system in space, by Herschel, has since been confirmed by the investigations of Argelander, and placed beyond a doubt; but it did not explain the motions of the double stars with respect to each other. In 1785, Sir William Herschel first suspected the true cause of these changes to be a revolution of one of the stars round the other, like that of a planet round the sun, conformably to the suggestion of Mitchel. In 1802, he first published this discovery to the world with the proofs on which it rested. Since that period much labour has been bestowed on this subject, by the elder and younger Herschel, Struve, South, Bessel, Mædler, and others. The most extensive work on double stars was published by Struve, in 1827, giving a perfect catalogue of 3112 double and multiple stars, observed by himself. In 1837, he published another work, containing a minute description of each of the pairs of stars in his first work. M. Savary first published a me-

thod of computing the orbits of the double stars; but to Sir John F. W. Herschel belongs the honour of first inventing a peculiar method—partly graphic or tentative, and partly analytical—of computing these orbits. He applied it successfully to several pairs. Encke has since published an analytic method for effecting the same. Encke's method, in the hands of Mædler, has been successful in perfecting the first sketches of these orbits by the younger Herschel.

The Appendix will contain Mædler's recent catalogue of all the known orbits of these double stars. They will occasionally be repeated in describing the constellations where they occur.

The number of pairs and multiples of stars within 32″ of each other, and having one member of the system as great as the 8th magnitude, is about 4,000, or about one in every forty of the stars of the 8th magnitude and upwards. This proportion is far greater than would follow from a uniform distribution of stars in the celestial spaces, as mentioned in the last section, and leads us at once to conclude that this great prevalence of double and multiple stars must be owing to some physical connexion between the individuals composing them. Such stars are said to be *physically* double or multiple. They are also called *binary, ternary,* &c. In the nature of things there must be another class of double and multiple stars, of which one is placed nearly behind the other; but perhaps as far beyond it as the other is distant from the sun. Such stars—whose apparent nearness is the result of their accidental position in space, as seen nearly in a line with

each other from the earth, and has no relation to real proximity or systematic association—are said to be *optically* double or multiple.

In describing the *binary* stars, they are said to revolve around each other. In reality each revolves around the common centre of gravity of the two bodies. When more than two stars form a multiple system, they revolve around the common centre of the system. It has not been possible as yet to determine the comparative masses of the individuals composing any of the double or multiple stars: Hence the position of the centres of gravity of the multiple systems is unknown, and consequently the period of each star round that centre is also unknown. But it is customary to say that two stars revolve round each other, or the less round the greater, whenever the line joining the two stars is found to make a complete revolution, returning to its first position after every circuit of 360°.

It has been stated that the pairs or multiples of stars in which a change of position or distance takes place, are *physically* double, or multiple. They are said to be thus *physically* connected, from their being acted on by some common force which causes their motions. This force, in several pairs of double stars, has been shown to be that of universal or Newtonian gravity. But there is a great difference between these *physically* double or multiple stars and our own solar system; for we have only one sun with a few planets and satellites, while the splendid stellar systems are composed of two or more *suns* revolving about a common centre. In some of the stars that are *physically* double, the Newtonian law of gravity has not yet been shown to prevail; but

from the fact that it extends throughout our solar system, and to many of the *binary* and *multiple* stellar systems, analogy leads us to extend it to all.

The most remarkable double and multiple stars (whether *physical* or *optical*) are pointed out in the description of each constellation.

If we suppose an average to prevail in the distribution of the stars, with respect to numbers, size, brilliancy, and distances apart, there should be in the whole heavens about 200,000 stars of the first eight magnitudes; and of these we should have, by this law, only one pair of *optically* double stars situated within 4″, three pairs from 4″ to 8″ apart, fourteen pairs from 8″ to 16″, and fifty-four pairs from 16″ to 32″ apart. Now it is found from actual observation that there are, in the region of the heavens north of the fifteenth parallel of south declination, the following numbers of pairs of stars each of the first eight magnitudes.

| | | | |
|---|---|---|---|
| 62 | stars | distant from | 0″ to 1″ |
| 116 | " | " | 1″ to 2″ |
| 133 | " | " | 2″ to 4″ |
| 130 | " | " | 4″ to 8″ |
| 106 | " | " | 8″ to 16″ |
| 106 | " | " | 16″ to 32′ |

Whereas, by average, there should be only about 48 optically double stars within this region. The remaining 605 may be supposed to have some physical connexion with each other. The indications of this connexion are a change of the bearing or distance of the stars from year to year, or something peculiar to the pair in their proper motions among the stars. The period through which observations have been made is too short to afford a classification of all the pairs of double stars in this respect. Struve has, however, ascertained that 90 of these stellar systems give indications of a periodical change of bearing and distance. Doubtless many of the remaining 563 double stars within

32″ of each other, supposed to be binary, will, in the course of long-continued observations, exhibit proofs of some physical connexion.

Of the triple and multiple stars, nearly all are supposed to compose physical systems, since in a distribution of 200,000 stars at random on the surface of the sphere, only one triple or multiple star should be expected to occur within a circle of 32″ diameter; whereas 68 triple or multiple stars within that limit have been already discovered. The Appendix will contain a list of the principal stars known from their relative motions to be physically double or multiple, and also a similar list of those which are presumed to be such from their having the same proper motion among the other stars. Mædler, in 1843, estimated the number of known *binary* and *ternary* stars to be about 250.

---

## SEC. 7.

### COMETS.

THE Comets will be described hereafter. They are sometimes seen in the starry heavens; but their motions are so extremely irregular as to exclude them from notice in a general description of the heavens.

---

## SEC. 8.

### VARIABLE STARS.

THERE are several stars which, though not distinguishable from others by any change of place, or by any difference of appearance when viewed with a telescope, yet undergo a regular periodical increase and diminution of brilliancy.

These are called *variable stars.* The following table contains the most remarkable stars of this kind which have yet been observed, with their right ascensions and declinations for 1800, their periods, or the number of days elapsing between two successive returns to the greatest or least brilliancy, and their apparent magnitudes at the times of their greatest and least brightness. The apparent magnitude 0 indicates that the star is invisible at the time of greatest obscurity.

| Star's Name. | Right Ascension. | Declination. | Period. | Magnitudes. | |
|---|---|---|---|---|---|
| | | | | Greatest. | Least. |
| o Ceti..... | 32° 19′ | 3° 53′S. | 331.96 days. | 2 | 0 |
| β Persei ... | 43 48 | 40 11 N. | 2.8673 " | 2 | 4 |
| Leonis... | 144 12 | 12 21 N. | 311.4 " | 5 | 10 |
| Virginis.. | 187 5 | 8 5 N. | 145.46 " | 6 | 0 |
| Hydræ... | 199 42 | 22 15 S. | 494. " | 3 | 0 |
| Serpentis. | 218 4 | 15 3 N. | 353. " | 8 | 0 |
| Coronæ.. | 235 5 | 28 47 N. | 335. " | 6 | 0 |
| Serpentis. | 235 22 | 15 45 N. | 340. " | 5 | 0 |
| α Herculis.. | 256 23 | 13 37 N. | 60.5 " | 3 | 4 |
| Scuti Sob. | 279 12 | 4 54 S. | 60.6 " | 5 | 7 |
| β Lyræ.... | 280 41 | 33 9 N. | 6.44 " | 3 | 5 |
| η Antinoi .. | 295 34 | 0 30 N. | 7.17 " | 4 | 5 |
| Cygni ... | 294 43 | 32 25 N. | 407.5 " | 4 | 0 |
| δ Cephei... | 335 26 | 57 24 N. | 5.36 " | 3 | 4 |
| Aquarii .. | 353 32 | 16 23 S. | 382.5 " | 6 | 0 |

The first of these o Ceti, or *Mira*, undergoes the greatest change of light, of all the variable stars yet discovered, since it varies from the second magnitude to invisibility. This remarkable phenomenon was first noticed by David Fabricius, in 1596. From a discussion of all the observations made upon the light of this star, Professor Wurm

has determined the above period of 331.96 days, and given a table for its variations of light. According to Bianchi of Modena, it attained its greatest brilliancy about the 1st of October, 1839. This event occurs about a month earlier each succeeding year. In 1844 it should be most brilliant early in May. And its increase of light is much more rapid than its decrease. It increases from the sixth magnitude to the second in 40 days, and continues of this degree of brilliancy 26 days, after which it diminishes to the sixth magnitude again in 66 days; hence it is during 132 days greater and during 200 days smaller than a star of the sixth magnitude.

The star $\beta$ Persei, or *Algol*, in the Head of Medusa, is of the second magnitude when at its greatest brilliancy, or equal to $\alpha$ Persei above it. Its vicissitudes of light are of a kind peculiar to itself. It continues visible as a star of the second magnitude for the space of 61 hours, then its light begins suddenly to diminish, and in 4 hours it becomes of the fourth magnitude, or about equal in brilliancy to the neighbouring star $\rho$. It remains at this magnitude 18 minutes without any sensible change, and then in the succeeding 4h. 40m. increases to the second magnitude again, in which state it remains 61 hours. Another peculiarity of this star is, that through all its changes it shines with a white light, while the colour of all the other variable stars is red.

With the above period of 2.8673 days, and the epoch of its least light, 1800, January 0d. 17h.

54m. 50.6s., Mean Paris Time, the times of its greatest and least brilliancy can be easily computed for any year. The variation of light experienced by this star was discovered by Goodricke, in 1783.

The variable star in the Lion was first observed by Koch, in 1780. The increase of its light occupies 85, and the diminution 140 days.

The star in the Virgin was first observed to be variable by Harding. Wurm determined its period to be 145.46 days, and the epoch of its greatest brilliancy 1820, 11th February, at 18 hours Mean Paris Time. In this instance also, the increase of light is more rapid than the diminution.

The variation in the light of the star in the Hydra was first detected by Montanari, in 1672.

The two stars in the Serpent were discovered by Harding, in 1828, as variable stars.

The star in the Crown, discovered by Pigott, in 1782, presents a wonderful anomaly in the variation of its light. It sometimes remains for several years without any apparent change, and then again manifestly varies according to the period and magnitudes given in the above table.

The double star $\alpha$ Herculis, or *Ras Algethi*, was found to be variable by the elder Herschel, in 1795. The increase of its light occupies 22, and the diminution 39 days.

The star in Sobieski's Shield and $\eta$ Antinoi, were discovered as variable by Pigott, in 1784

and 1795; $\beta$ Lyræ and $\delta$ Cephei, by Goodricke, in 1784; the star in the Swan, by Kirch, in 1686 and that in Aquarius, by Harding, in 1811. There are, doubtless, many more such stars in the heavens yet undiscovered. Indeed our knowledge of the periods and epochs of many of those in the above list is quite imperfect.

From all the observations hitherto made upon changeable stars, it appears that their light is red or of a copper colour; that its increase and diminution take place with unequal rapidity; that their phase of least light lasts much longer than that of their greatest light; and that their periods and the brilliancy of the different phases are subject to anomalies and perturbations, of the cause of which we are as yet ignorant. The star Algol forms a remarkable exception to these rules, otherwise general.

Various causes have been assigned for this remarkable variation of light. Some have supposed that these variable stars, like our sun, have a rotation on their axis, and that one side of them is either wholly dark or partly covered with dark spots, like those seen on the disc of the sun. Others, that these stars are lens-shaped, and that their light diminishes or completely vanishes when they are turned edgewise towards us. These variations have also been attributed to atmospheric changes, peculiar to these stars. Opaque satellites intervening might also diminish their light.

## NEW AND LOST STARS.

Pliny mentions, in his Natural History, that a *new* star appeared in the heavens about 125 years B. C. This circumstance induced Hipparchus to make a catalogue of the principal stars, in order to enable astronomers to detect similar occurrences in future. In A. D. 389, in the time of Cæsar Honorius, there appeared in the constellation of the Eagle, according to Suspinianus, a star as bright as Venus, which remained about three weeks and then vanished. In the ninth century, two Arabian astronomers saw a new star in the Scorpion, as bright as the moon at her quarters. It disappeared after about four months. In the reign of the Emperor Otho, 945 A. D., the chronicles mention such a new star, between Cepheus and Cassiopeia. A similar star was discovered in the same place, in 1572, by Tycho Brahe. It continued without motion or change of brightness for near two years, and then suddenly began to wane, and finally disappeared. When first discovered, it was *white*, two months afterwards *yellow*, and finally it became as *red* as Mars or Aldebaran. Before disappearance, its light became pale, like that of Saturn. Some have supposed the stars of 945, 1264, and 1572, to be the same variable star.

In 1604, a star appeared in the *Serpent Bearer*, nearly as bright as that of 1572. Kepler wrote a work on the subject of this star. It disappeared

in 1605. In 1670, Anthelm discovered a star of the third magnitude in the *Swan*. At the end of two months, it decreased to the fifth magnitude, and shortly afterwards vanished. Dominic Cassini observed this star with great care.

Many stars mentioned in the old catalogues cannot now be found. Some have doubtless disappeared, and some were probably inserted erroneously in these catalogues. The cause of the disappearance of these stars, is matter of mere conjecture. Newton supposed that they were planets suddenly ignited by coming in contact with their suns.

---

## SEC. 9.

### NEBULÆ AND CLUSTERS OF STARS.

The tendency to the formation of groups or clusters of stars in the heavens, has already been noticed: as examples we may mention the Pleiades or seven stars, Berenice's Hair, the Manger in the Crab, and the Sword of Perseus. These are the most striking groups as seen by the naked eye. The Milky-Way abounds throughout in white nebulous matter, from which it takes its name. This portion, which is white and cloudy to the naked eye, is in reality composed of a multitude of small stars, whose single light is too feeble to make a sensible impression, but when combined

in great numbers, they produce the appearance of a thin white cloud.

This illusion is removed by a small telescope, which brings to view the individuals composing this immense group, and proves that it consists of myriads of stars. We may form some idea of their number, when we are told by Sir William Herschel that 50,000 of them passed through the field of his great telescope in the course of an hour, in a zone only 2° broad. It was a brilliant idea of Herschel, that our sun and its system is situated within an immense nebula or cluster of stars, perhaps somewhat hollow, of an oval or lenticular shape. Succeeding astronomers have found that the stars are most widely scattered in the portions of the heavens most distant from the Milky-Way, and that the condensation or thickening of the stars increases in approaching this region.

The regular shape of this wonderful zone of countless stars, shows that there is an isolated system of suns in the heavens, of which our own sun forms a component part. It is probably of the form of a lens, having our sun not far from the plane passing through the centre. In this plane, however, our system is placed at some distance from the central part, in a direction towards the portion of the milky-way near the constellations of Sirius and Orion. No one who glances at this portion of the heavens in the winter evenings, even without the aid of instruments, can for a

moment doubt of the truth of this remark. Perhaps the milky-way belongs to the class of hollow nebulæ, like the annular nebula in Lyra. If our system were not situated in the plane passing nearly through the centre of the milky-way, we should no longer see it as a great zone, but only as a smaller portion of the heavens.

If the sun was placed in the direction of its shortest axis, and at a distance as great as its longest axis, or diameter of its disc, we should see it as a great white cloud of 60° breadth, or of the size of the Great Bear. At ten diameters' distance it would cover only 6°, and at two hundred such diameters' distance it would be no larger than some of the nebulæ of the first class in the heavens, for instance, the nebula in Andromeda or Orion.

The nebulous region of the heavens embraces a zone as broad as the milky-way, and perpendicular to it, passing through the equinoxes. The most nebulous portion of this zone is its intersection with the constellations of the Virgin and Berenice's Locks. See Plate XVII. Fig. 19th. Here the nebulæ follow each other in rapid succession, by the diurnal motion of the heavens, while in some parts of the heavens hours elapse after one of them has passed through the field of the telescope before another enters.

In examining the heavens with ordinary telescopes, many small *milky-ways* or nebulous portions are seen which, with more powerful instru-

ments, are resolved into multitudes of stars closely clustered together, seeming like a globular space, insulated in the heavens and constituting a system by itself, subject only to its own internal laws. Many of these *resolvable nebulæ* have ten thousand stars in a surface one-tenth as large as that which is covered by the moon, so that its centre where the stars are seen projected on each other is one blaze of light.

If all these stars are suns, separated by intervals as great as that of our sun from the nearest fixed star, the distance, which renders the whole cluster barely visible to the naked eye, must be so great that light would occupy at least a thousand years in coming to us from this splendid assemblage. Occasionally, clusters are so irregular in their outline, as merely to suggest the idea of a rich portion of the heavens. These contain fewer stars than the *globular clusters,* and frequently include one much more conspicuous and clearly defined than the rest. Sir William Herschel regarded them as the rudiments of *globular clusters,* in a less advanced state of condensation, but tending to that form by their mutual attraction.

Multitudes of nebulous spots are seen scattered throughout the heavens, having every appearance of clusters like those described above, but too distant to be resolved into stars by the best telescopes that have yet been made. Notwithstanding this circumstance, from their general resem-

blance to the globular clusters, when seen through telescopes of moderate power, they are referred to the class of *resolvable nebulæ.*

Numbers of these nebulous spots give no indication of a stellar nature, but appear to be matter in the highest possible degree of rarefaction. These are denominated *irresolvable nebulæ.* They are in every state of condensation, from a vague film scarcely to be discerned with the most powerful telescopes, to such as seem to have actually arrived at a solid nucleus. The nebulæ of this class are of every variety of form and appearance. The most remarkable are those represented in figs. 59 & 51, plate XVIII., surrounding the star $\theta$ in the constellation of Orion, and $\eta$ in the southern constellation Robur Caroli. The nebulous character of these objects, especially of the former, is very different from what might be supposed to arise from the diffused light of an immense collection of small stars. They resemble light flocky masses, like wisps of cloud; and such wisps seem to adhere to many small stars at their outskirts: one of them, of a curious form, is represented in the figure. These and all the other figures of nebulæ, are copied from original drawings by Sir John Herschel. Some are of an annular form, but they are very rare. The most conspicuous of these objects is to be found midway between $\beta$ and $\gamma$ Lyræ, and may be seen with telescopes of moderate power. It is elliptical in the ratio of 4 to 5, and is sharply defined. The internal

opening, occupying about half its diameter, is not entirely dark, but filled with a faint, hazy light. Sir John Herschel compares it to fine gauze stretched over a hoop.

*Planetary nebulæ* form another class of very extraordinary objects. They have the appearance of planets; round or slightly oval discs, in some instances quite sharply terminated, in others hazy and ill defined, and with a light exactly equable or a little mottled, occasionally rivaling that of the planets in vividness. These nebulæ are of enormous dimensions. The apparent diameters of some of them are from 12″ to 20″; and supposing them to be at the distance of the fixed stars, their real magnitudes must, at the lowest estimation, be such as to fill the orbit of Uranus, which is between three and four billions of miles in diameter.

*Stellar nebulæ* form a fourth class. These have a round or oval shape, increasing in density towards the centre. In some the condensation is slight and very gradual; in others so sudden, as to give to the whole the appearance of a star with a burr around it, or a candle shining through horn. In others the central matter is so highly and suddenly condensed, and so vivid, as to offer the appearance of sharp and brilliant stars, surrounded by thin atmospheres. These are called *nebulous stars*. There is a very fine example of this class in the constellation Andromeda, in R. A. 25° 45′, Dec. 39° 53′: ε and ι Orionis are also nebulous,

but the nebulæ can only be seen with very powerful telescopes.

The zodiacal light is a thin, lens-shaped atmosphere, surrounding the sun and extending beyond the orbits of Mercury and Venus, which may be seen soon after sunset in the months of April and May, or at the opposite seasons before sunrise, as a cone of light extending obliquely upwards nearly in the direction of the ecliptic. This phenomenon seems to indicate some slight degree of nebulosity about our sun, and even to place it on the list of nebulous stars. The stellar nebulæ and nebulous stars assume all degrees of ellipticity. Some are only slightly elliptical; others much extended in length; and some are long and narrow, like a spindle-shaped ray, tapering away at both ends, with a bright nucleus in the centre. One of the most remarkable specimens of this kind is in R. A. 187° 0′, Dec. 26° 56′.

In plates XVII. and XVIII. will be found representations of the most interesting nebulæ of all classes. A full description of each is given in sec. 15.

The distribution of the nebulæ over the heavens is even more irregular than that of the stars. They are most abundant in a zone whose general direction is not far from the hour-circle of 0h. and 12h. Where that zone crosses the constellations Virgo, Coma Berenices, and the Great Bear, they are assembled in great numbers; but they are for

the most part beyond the reach of any but the most powerful telescopes.

In some instances double or multiple nebulæ are found presenting a close analogy with the binary and multiple stars. It is highly probable that such systems of nebulæ are bound together by some law of attraction, like that which connects the physically double stars. As yet no such law has been detected; the study is still in its infancy, and the double nebulæ do not admit of precise measures like the double stars.

The number of nebulæ at present known, is about 3000. These have all been described by the younger Herschel. Of these, near 2000 were discovered and described by Sir William Herschel. From comparison of the early and recent drawings of the great nebula in Orion, there is reason to suppose that a change is going on in its appearance, and perhaps in its physical condition. Mrs. Somerville remarks, that "the nature and use of this nebulous matter, scattered over the heavens in such a variety of forms, is involved in the greatest obscurity. That it is a self-luminous, phosphorescent, material substance, in a highly dilated or gaseous state, but gradually subsiding by the mutual gravitation of its particles into stars and sidereal systems, is the hypothesis most generally received. And indeed this is the hypothesis of La Place with regard to the origin of the solar system, which he conceived to be formed by the successive condensations of a nebula, whose

primeval rotation is still maintained in the rotation and revolution of the sun and all the bodies of the solar system in the same direction. Even at this day there is presumptive evidence in the structure and internal heat of the earth, of its having been at one period in a gaseous state from intensely high temperature. But the only way that any real knowledge on this mysterious subject can be obtained, is by the determination of the form, place, and present state of each individual nebula; and a comparison of these with future observations will show generations to come the changes that may now be going on in these supposed rudiments of future systems."

Having now completed the outline of the various classes of bodies which stud the brilliant vault enclosing our own humble solar system, the reader will find in the explanation of the maps and the descriptions of the several constellations presented in the succeeding sections, an available guide in the study of the starry heavens. Let him look out upon the deep, clear, blue, mysterious Night, and with this guide converse with Nature in her unfathomable depths. Here he may wander among blazing suns, wheeling in awful majesty, self-poised, around a common centre in the void of space. There, among multitudes of nascent orbs of vapour, silent and seemingly motionless, but gradually preparing, as it well may be, for future usefulness and beauty. Again, where the huge planetary nebula spreads out its giant masses

over an extent of space deemed almost infinite by the uneducated, yet reduced by distance to a glimmering speck. Let him become familiar with these almost unimaginable wonders. Then, returning in thought to this little ball — invisible from the nearest star—on which so many millions perpetually contend for *power* and *greatness*, let him ask for whom, for what, or why was made this universe of brightness! If he be not rendered wiser, better, humbler by the enquiry, *for him* these glories have been made in vain.

---

## SEC. 10.

### DESCRIPTION OF THE MAPS.

THE first two maps represent the Northern and Southern Hemispheres. In these the graduated circle represents the equator; the centres, the poles; the meridians or declination circles would be diameters of this circle; and the parallels of declination, circles concentric with it. The equator is divided into degrees, which are numbered from the vernal equinox eastward round the circle. The meridian passing through 360° and 180° is the equinoctial colure; the lower half of this diameter is divided into nine equal parts, these divisions corresponding to the even tens of the degrees of declination; they are numbered accordingly from the equator toward the poles. The right ascensions and declinations of the stars may

be very readily found upon these maps by means of a scale and dividers. The R. A. is indicated by the point where the radius drawn through the star cuts the equator. The Dec. may be determined by measuring the distance on this radius from the star to the equator, considering the radius equal to 90°.

The next five maps represent sections of the northern hemisphere upon the same plan as the first, but on a much larger scale. In these the parallels and declination circles for every tenth degree are drawn. The parallels are numbered on two of the meridians, and the meridians around the borders of the maps. As the right ascension is often expressed in time, each hour being equal to fifteen degrees, the corresponding hour is indicated by the Roman numeral placed without the border at each fifteenth degree.

The eighth and ninth maps represent portions of the equatorial regions upon a different plan from the preceding, the equator and parallels being straight lines, and the meridians also straight lines crossing them at right angles. The meridians are numbered at the top and bottom, and the parallels at the sides.

The next five represent portions of the southern hemisphere; they are similar to those of the northern sections.

The fifteenth contains the principal stars of the northern hemisphere, connected by lines so as to form a variety of geometrical figures. It is to be

used in studying the positions of the stars by the process of *lining*.

## SEC. 11.

### DESCRIPTION OF THE CONSTELLATIONS.

PLATE III.

CONSTELLATIONS.

| | |
|---|---|
| Ursa Minor . . . | *The Little Bear.* |
| Cepheus . . . . | *The King.* |
| Draco . . . . . | *The Dragon.* |
| Honores Frederici . | *Frederick's Honours.* |
| Lacerta . . . . | *The Lizard.* |
| Canes Venatici . . | *The Grey-Hounds.* |
| Quadrans Muralis . | *The Mural Quadrant.* |
| Cygnus . . . . . | *The Swan.* |

### URSA MINOR—*The Little Bear.*

This is a small constellation near the Great Bear. In both these the seven principal stars constitute a figure called by some a wagon, and by others a dipper. In the Little Bear there are five stars of the 4th and two of the 5th magnitude, forming the little wagon, having the pole star at the end of the pole or beam. The four principal stars in this constellation are:

$\alpha$, *Polaris, Ruccaba,* or *Cynosura.*
$\beta$, *Kochab.*
$\gamma$, *Pherkad.*
$\delta$, *Vildiur.*

The Pole Star is of the 2d magnitude, of a yellow colour, and has at the distance of 18″ a small white star of the 9th magnitude as a companion. See plate XVI., Fig. 9. Among the other double stars are,

$\pi^1$ R. A. 234° 50′, Dec. 81° 1′, the components are of the 6th and 7th magnitudes, 30″ apart, both yellowish white.

$\pi^2$ R. A. 237° 26′, Dec. 80° 29′, 7th and 8th magnitudes, both very white, $\frac{7}{10}$″ apart.

MYTHOLOGICAL HISTORY OF THIS CONSTELLATION,

OR

FABLE.

The nymph Calisto and her son Arcas being turned into bears by Juno, Jupiter, to prevent their being hurt by huntsmen, transferred them to the heavens, in the form of the constellations Ursæ Major and Minor.—Or, according to other legends, Cynosura was a nymph of Ida, in Crete, who nursed Jupiter, and was by him rewarded with a place in the heavens. THALES is reputed to have formed the constellation of Ursa Minor, by which the Phœnicians are said to have sailed; and for this reason the polar star is sometimes called *Phœnice*.

## CEPHEUS—*The King.*

CEPHEUS is between the Lesser Bear and the milky-way. It may be readily known by the three stars $\alpha$, $\beta$, and $\gamma$, of the third magnitude, which stand nearly in a right line, and by four of

the fourth magnitude, δ, ε, ζ, and ♋, which make ♌ covering for his head.

α *Alderamin.*
β *Alphirk.*
γ *Errai.*

β is a double star. Its components are of the 3d and 8th magnitudes, distant 13″, the greater greenish white, the smaller blue.

κ is a double star of the 4th and 8th magnitudes, distant 7″, the greater greenish white, the smaller blue.

ξ on the neck, is a double star of the 5th and 7th magnitudes, distant 5″, the greater yellowish white, the smaller ash-green.

ο is a double star of the 5th and 8th magnitudes, distant 2½ seconds, the greater deep yellow, the smaller deep blue.

The star δ, in the crown of Cepheus, is variable. In the space of two days it changes from the 3d to the 4th magnitude.

In R. A. 357° 0′, and Dec. 60° 16′, north of β Cassiopeiæ, is a very rich cluster of stars of 4′ diameter. The stars of this cluster are nearly all of the 9th magnitude.

In R. A. 1° 0′, and Dec. 71° 35′ is a star of the 8th magnitude, contained in a well-defined nebular sphere, 20″ in diameter.

### FABLE.

Cepheus was an Ethiopian or Indian King, husband of Cassiopeia, and father to Andromeda. He was one of the Argonauts, and changed into a constellation after death. He is represented in the habit of an Eastern monarch, with a sceptre in one hand, and holding his robes with the other.

## Draco—*The Dragon.*

This constellation winds itself, with the fore-part, around the Pole of the Ecliptic, and with

the other around the Sittle Bear. The Pole of the Ecliptic is in R. A. 270°, and Dec. 66° 33′. This constellation is composed, for the most part, of stars of the 2d, 3d and 4th magnitudes, whose situation makes it easily distinguishable. The head consists of four stars, two of the 2d and two of the 3d magnitude, forming an irregular quadrangle. Between the head and the tail there are three coils; the first, containing nine small stars, is about 15° distant from the head, and at about the same distance from the Pole as the head; the second and third coils are on opposite sides of a line joining the Dragon's head with the Pole Star, and about midway between them. These contain each a star of the 3d magnitude, and several smaller ones. Between the third coil and the end of the tail are six stars of the 3d magnitude, which nearly encompass the Little Bear: they are named $\eta$, $\theta$, $\iota$, $\alpha$, $\varkappa$ and $\gamma$, the last being nearly in a line joining the Pointers in the Great Bear. $\alpha$ is remarkable as having been the *Pole Star* about 4600 years ago.

| | |
|---|---|
| $\alpha$ *Phuban.* | $\tau$ *Gianzar.* |
| $\beta$ *Alwaid.* | $\mu$ *Arrakis.* |
| $\gamma$ *Etamin.* | $\xi$ *Grumium.* |
| $\delta$ *Nodus II.* | $\mu$ *Errakis.* |
| $\zeta$ *Nodus I.* | $\downarrow$ *Dsiban.* |
| $\theta$ *Aldib.* | $\sigma$ *Alsaphi.* |

Among the double stars are,

$\varepsilon$ Its components are of the 4th and 7th magnitudes, distant 3″, the greater yellow, the smaller blue.

$\eta$ of the 2d and 8th magnitudes, distant 3″, recently discovered by Struve at the Pulkova Observatory.

$\mu$ in the tongue, both white, of the 5th magnitude, distant 4″.

$\psi$ of the 4th and 5th magnitude, distant 31″, both white. Their proper motion among the other stars is 27″ in a century.

R. A. 248° 3′, Dec. 53° 15′, in the end of the tongue, near $\varkappa$, of the 5th and 6th magnitudes, distant 4″ both white.

FABLE.

Draco, the offspring of Typhon, with a hundred heads and as many voices, was the guardian of the golden apples which grew in the garden of the Hesperides. It was one of the labours of Hercules to obtain some of these apples, and he slew the Dragon in order to get at them, upon which Juno translated the reptile to the heavens. This fable is evidently founded upon the part acted by the serpent in the fall of our first parents; in consequence of which they and their posterity were excluded from the fruit of the tree of life, till One greater than Hercules should destroy him, and restore man to the primeval state of innocence and happiness.

## Lacerta—*The Lizard.*

This constellation was formed by Hevelius.

Among the multiple stars are,

R. A. 337° 3′, Dec. 38° 44′, a quadruple star; the components are of the 6th, 7th, 10th and 8th magnitudes; the two largest are remarkably white, distant 22″, the 2d and 3d are distant 28″, and the 2d and 4th are distant 66″.

R. A. 342° 5′, Dec. 40° 41′, a triple star of the 6th, 12th and 9th magnitudes; the greatest very white; the two largest are 63″ apart, the largest and smallest 28″.

---

HONORES FREDERICI—*The Honours of Frederick.*

Formed by Bode, in 1787, in memory of Frederick II.

---

CANES VENATICI—*The Grey Hounds,*

Is a recent constellation formed by Hevelius. It contains none but small stars.

To the two Hounds which Bootes leads with a cord, Hevelius gave the names of Asterion and Chara, the former standing towards the north, the latter towards the south. To the star α, of the 3d magnitude, in the Collar of Chara, Halley has given the appellation of *Cor Caroli,* (Charles's Heart).

12 Canum Venaticorum is a double star, whose components are of the 3d and 6th magnitudes, both white, 20″ apart.

---

QUADRANS MURALIS—*The Mural Quadrant,*

Is a recent constellation formed by Lalande, in memory of the many valuable observations made by his nephew at the military school at Paris, with a mural quadrant.

---

## CYGNUS—*The Swan.*

Five of its largest stars, $\alpha$, $\beta$, $\gamma$, $\delta$ and $\varepsilon$, form a cross, by which this constellation is readily known. The whole constellation lies in the milky-way, besides which the northern part of the Swan is very rich in dense clusters of stars.

$\alpha$ *Deneb.*
$\beta$ *Albireo.*
$\gamma$ *Sadr.*
$\varepsilon$ *Ginah.*
$\pi$ *Azelfafage.*

In R. A. 314° 52′, Dec. 37° 56′, between $\upsilon$ and $\tau$, over the right wing of the Swan, stands a remarkable double star which is known by the name of "61 Cygni," according to Flamsteed's Catalogue. These stars are of the 5th and 6th magnitudes, both golden yellow, distant 16″. They revolve round each other in 540 years. The major axis of their elliptic orbit is 30″.8. Both stars have moreover a common and very great proper motion among the other stars in their vicinity, which amounts in a century to 511″ in right ascension, and 323″ in declination, or about 517″ in arc. This pair of stars will be for ever memorable for being the first whose distance from the earth was measured with precision. This great discovery was made by Bessel from his observations at Kœnigsberg in the years 1837, and 1838, and 1839 He found their distance 592 000 times the earth's mean distance from the sun, and that their light

travels to our system in $9\frac{1}{4}$ years. He also concludes that their two masses are, together, rather less than that of our sun. That is to say, that the mass of each of them is about one-third. Hence our sun seen from 61 Cygni, should appear as a star of about the 5th magnitude. Bessel was induced to select this pair of stars as the subject of his researches, from their great proper motion which he justly supposed to be an indication of their comparative nearness to our system. In making his researches, he compared them with two other small neighbouring stars of the 10th magnitude, which neither have sensible proper motion, nor parallax; that is to say, whose distance from our system is immeasurably great. Before this discovery was made, Sirius or the dog-star was supposed to be the nearest because he is the brightest of the stars. This may still be the case; but it seems more natural to conclude from Bessel's discovery, that the brightest stars are not always the nearest, and that they owe perhaps their great size and brilliancy to their real greatness of dimensions and intensity of light. In such a case, the stars of the first magnitude may possibly be many hundred times as great as our sun.

The attempt to discover the parallax and distance of the fixed stars, has been the cause of some of the greatest discoveries in astronomy. Bradley's discovery of aberration and nutation was the result of his researches after the parallax of the fixed stars. No other pursuit in astronomy

has engaged so much attention for the last two centuries. Bessel is exceedingly fortunate in having brought this long investigation to a successful issue.

The Swan contains many very remarkable double stars.

β is a double star, whose components are of the 4th and 6th magnitudes; distant 34″; the greater yellow, the smaller blue.

δ is a double star of the 3d and 8th magnitudes; distant 2″; the greater greenish, the smaller ash-coloured. They formerly appeared as a single star; they are now seen double through choice instruments.

λ is a double star, both of the 6th magnitude; distant four-fifths of a second; recently discovered by Struve, with the great Pulkovah refractor.

μ is a double star of the 4th and 5th magnitudes; distant 6″; the greater white, the smaller bluish white. Both stars have the same proper motion of 34″ in a century among the other stars.

χ in the neck, is a double star of the 5th and 8th magnitudes; distant 26″; the greater deep yellow, the smaller bluish. In 1686, Kirch discovered that the greater is a variable star. In 407 days, from being of the 4th magnitude, it disappears entirely, and then increases to the 4th magnitude. These two remarkable stars have a proper motion of 43″ in a century among the other stars.

In R. A. 287° 30′, Dec. 29° 53′, is a beautiful, very dense group of stars, without any precise nucleus. The whole has the form of a triangle, of which the greatest diameter is 3′. This group lies between the head of the Swan and Lyra.

In R. A. 321° 10′, Dec. 50° 50′, in the end of the tail, is a very large, beautiful, circular group of very small, densely clustered stars, in the middle of which there is a reddish star of the 8th magnitude. The whole is about 8′ in diameter.

In R. A. 324° 30′, Dec. 52° 55′, northward from the end of the tail, is a very remarkable oval ring of small, densely clustered stars. In the middle of the ring stands a reddish star of the 8th magnitude.

In R. A. 302° 15′, Dec. 30° 2′, midway between the stars b and n, is a very large planetary nebula of 15′ diameter. It is perfectly round, uniformly illuminated, except toward the centre, where it is somewhat darker, so that perhaps also this object is a planetary ring.

### FABLE.

Jupiter, in order to deceive Leda, assumed the figure of a swan, which he afterwards translated to the heavens. Or, according to another fancy of the mythologists, Orpheus, after he was murdered by the wild Bacchantes, was metamorphosed into a swan, and placed among the constellations.

---

## PLATE IV.

### CONSTELLATIONS.

| | |
|---|---|
| Ursa Major . . | *The Great Bear.* |
| Custos Messium . | *The Guardian of the Harvest.* |
| Camelopardalis . | *The Giraffe.* |
| Cassiopeia . . . | *The Lady in her Chair.* |
| Leo Minor . . . | *The Little Lion.* |
| Lynx . . . . | *The Lynx.* |
| Perseus et Caput Medusæ | *Perseus and Medusa's Head.* |
| Tarandus . . . | *The Reindeer.* |
| Telescopium Herschelii . . | *Herschel's Telescope.* |

## URSA MAJOR—*The Great Bear.*

The most important stars of this constellation, with their proper names, are:

| | |
|---|---|
| α *Dubhe.* | κ *Kaphza.* |
| β *Merak.* | λ *Tania Borealis.* |
| γ *Phekda.* | μ *Tania Australis.* |
| δ *Megrez.* | π *Muscida.* |
| ε *Alioth.* | ξ *Alula Australis.* |
| ζ *Mizar.* | ν *Alula Borealis.* |
| η *Benetnash* or *Alhaid* | ϱ *Alcor.* |
| ι *Talita.* | |

The first seven of these stars, owing to their magnitude and remarkable situation, have been known from great antiquity under the appellation of the Great Dipper; it is also sometimes called *Charles's Wain.* Two of these, α and β, are denominated the *pointers,* because a line drawn through them would, if produced, pass very near the *Pole Star.* These seven stars cannot fail to be recognized at a glance; the other principal stars may be found by attending to the following directions. A line drawn from δ through γ, and produced to the extent of nearly twice their distance from each other, will terminate near the star ψ, of the 3d magnitude, in the right hinder leg. A line drawn from β through ψ, and prolonged about their distance, will terminate near two stars, ξ and ν, of the 4th magnitude, in the left hinder foot. The stars μ and λ, of the 3d magnitude, in the right hinder foot, may be found by conceiving a

right-angled triangle to be formed by joining $\psi$ and the two hinder feet, the line joining the two feet being the hypothenuse. This hypothenuse continued a distance equal to its length from the right hinder foot will terminate in the right fore-foot where are two stars, $\iota$ and $\varkappa$, the one of the 3d and the other of the 4th magnitude. In a line joining $\iota$ with $\beta$, and a little more than one-third their distance from $\iota$, is the star $\theta$ of the 3d magnitude, in the right fore leg. The Bear's head, which contains two stars of the 4th and five of the 5th magnitude, is between the fore-foot and the Pole, and on a line with $\delta$ and $\alpha$ in the back.

There are several remarkable double stars in this constellation.

$\zeta$ or *Mizar*, whose components are of the 2d and 4th magnitudes; both greenish white; distant 14″. They may be seen double in a common spy-glass. Northerly from this stands the small star $\varrho$ called Alcor.

$\xi$ or *Alula Australis*, in the lower end of the left hinder foot, of the 4th and 5th magnitudes; distant 2″. The period of their revolution round each other is $60\frac{1}{2}$ years. Their mean distance is $2\frac{1}{4}$ seconds; their eccentricity $\frac{2}{3}$ of this distance. Their period is about 20 years shorter than that of Uranus. They are also remarkable for their proper motion of 74″ in a century.

$\nu$ of the 4th and 10th magnitudes; very yellow; 7″ apart.

Of the many nebulæ of this constellation, the most remarkable are the following:

In R. A. 127° 45′, Dec. 50° 49′, at the end of the fore-feet, is a large, bright, elliptical nebula, of 30′ length and 20″ width, with a light star in the middle.

In R. A. 145° 15′, Dec. 69° 52′, on the right ear of the

Bear, a large, light, elliptical nebula, from whose centre rays of from 3′ to 4′ length shoot out.

In R. A. 175° 45′, Dec. 45° 4′, southward from the star $\chi$, a very beautiful, sharply defined, spherical nebula, with a bright nucleus. The diameter of the whole is 3′.

In R. A. 131° 45′, Dec. 54° 25′, near the star $\varepsilon$ in the fore-foot, a star of the 11th magnitude, with a fan-like nebula joined to it.

In R. A. 200° 30′, Dec. 48° 5′, under the star $\eta$ in the end of the tail, a very remarkable object and one very difficult to determine. A spherical-formed light body, surrounded by a concentric nebulous ring, which appears to be broken.

FABLE, (*See Ursa Minor*).

---

CUSTOS MESSIUM—*The Guardian of the Harvests.*

This new constellation, sometimes called the *Shepherd*, was instituted by Lalande about the middle of the last century, in honour of the zealous astronomer Messier of Paris. It lies between the constellations of Cassiopœia and the *Reindeer*, and contains only small stars.

This constellation contains a remarkable *quintuple* star, R. A. 58° 1′, Dec. 61° 52′. The two brightest components are of the 6th magnitude, distant 18″; the first white, the second bluish white. The three others are of the 9th magnitude. Their distances are as follows:—2d and 3d stars, 49″; 3d and 4th stars, 5″; of the 4th and 5th, 23″.

---

CAMELOPARDALIS—*The Giraffe.*

Was instituted by Hevelius in the beginning of the 17th century, and, like the preceding, contains only small stars.

Among them we remark a beautiful double star, in R. A. 54° 40′, Dec. 53° 30′, between the hoofs of the two hinder feet. The two stars are of the 5th and 6th magnitudes, and their distance is 10″; the greater appears white, and the smaller bluish white.

---

CASSIOPEIA.—*The Lady in her Chair.*

This constellation is on the side of the *Pole Star* opposite to the Great Bear, and nearly at the same distance from it. The five principal stars are:

α *Schedir.*
β *Caph.*
γ
δ *Rueba.*
ε

α, β and γ form a triangle, right-angled at α; δ and ε are in a line parallel to the line joining α and γ, and at the same distance apart as those stars. The star β is somewhat the brightest of the five; it serves to determine the position of the North Pole; for this star and the Pole star are placed on the same side of the true Pole, lying in a line with it, while the former is about a degree and a half more distant from it than the latter. The North Pole is the middle of a line joining β of Cassiopœia and δ of the Great Bear. Besides these there are several smaller stars, which may be easily recognized in the heavens, by observing their bearings and distances with reference to the five principal stars.

Northward from the star κ Tycho Brahe disco-

vered, about the end of the year 1572, a new, very bright fixed star, which, surpassing even Jupiter and Sirius in brilliancy, was visible in the daytime, but it gradually became fainter, and finally disappeared entirely in March 1574.

The star $\mu$ in the left arm, has, among all single fixed stars, the greatest proper motion, which amounts during a century to 571″ in Right Ascension, and 150″ in Declination. This star has, therefore, since the birth of Christ, advanced among the other stars about 2° 51′, or nearly six times the moon's diameter.

Among the double stars we remark,

$\eta$ the components of which are of the 4th and 8th magnitudes; distant 9″; the greater yellow, the smaller purple. These two stars have the same proper motion among the other stars, of 119″ in a century.

$\iota$ Triple, of the 4th, 7th and 8th magnitudes; distant 2″, and 8″; the first is yellow, the others blue.

$\psi$ Triple, of the 4th, 9th and 9th magnitudes; distant 32′ and 3″; the brightest is deep yellow.

$\sigma$ in the right arm, of the 5th and 7th magnitudes; distant 3″; the greater deep green, the smaller deep blue.

R. A. 359° 17′, Dec. 57° 28′; of the 8th and 9th magnitudes; both yellow. They revolve round each other in 95 years, at a mean distance of $1\frac{1}{4}$ seconds. This stellar system is called 3042 Struve.

R. A. 357° 0′, Dec. 56° 46′, in the head of Cassiopœia, stands a beautiful, large, round group of stars, 15′ in diameter. It is a very rich, dense cluster of stars, which are all of the 9th and 10th magnitudes.

R. A. 17° 0′, Dec. 57° 26′, south of the star $\delta$, is found a double star of the 8th and 9th magnitudes, at the distance of 12′. It stands in the middle of a large spherical nebula.

FABLE.

Cassiopœia was the wife of Cepheus, and mother to Andromeda. She brought upon herself the vengeance of the Nereides, by boasting of her superior beauty; and Neptune, at the request of those jealous nymphs, sent a huge sea-monster to desolate the country. The wrath of Neptune was only to be appeased by the exposure of Cassiopœia's beloved daughter Andromeda to the fury of the monster; but, just as she was about to be devoured, Perseus arrived and delivered her. Cassiopœia was, after death, metamorphosed into a constellation. She is represented as seated in an antique chair, drawing her robe over her shoulder with her right hand, and raising a palm branch to her head with her left.

---

## Leo Minor.—*The Little Lion.*

This recent constellation was formed by Hevelius. It consists mostly of smaller stars, of which four of the 4th magnitude form a rectangle, by which the constellation may be easily known. It lies between the Great Bear and the Great Lion.

---

## Lynx.

This constellation was also established by Hevelius, and, like the preceding, is composed of small stars only.

R. A. 97°, and Dec. 59° 37′ is a triple star; two of the stars comprising it are only 2″ apart, and nearly 9″ each from the third. Its components are of the 5th, 6th and 7th magnitudes. The last two are greenish white, the most distant one is blue.

---

## Perseus et Caput Medusæ—*Perseus and Medusa's Head.*

This constellation lies between Camelopardalis and Taurus, in the middle of the milky-way.

α *Mirzak*, or *Algenib*, on the breast.
β *Algol*, in the Head of Medusa.
ξ *Menchib*, in the left calf.
υ *Nembus*, at the point of the sword.
ο *Atix*, by the heel of the left foot.

α, or Algenib, is the brightest star in this constellation; it may be easily recognized as being in the middle of a tolerably regular curve, formed of several stars, concave towards the Great Bear. From α towards ε of Cassiopœia, and distant from it about 5°, is γ on the right of the head of Perseus. A line drawn from the Pole Star to γ and produced just one-third their distance, will terminate in Algol. γ, β and δ form a triangle right-angled at δ and nearly isosceles.

Algol is remarkable for the peculiar changeableness of its light. At the time of its brightest light it is of the 2d magnitude, and nearly equal to α above it; 61 hours after it has attained the 2d magnitude, it suddenly begins to become fainter,

and diminishes in 4 hours to the 4th magnitude. It remains in this condition of minimum brightness 18 minutes, and in the following 4 hours and 40 minutes, it increases again to the 2d magnitude, in which state it continues 61 hours, and then begins to diminish again.

Among the double stars are,

$\varepsilon$ in the left knee of Perseus; its components are of the 3d and 8th magnitudes; distance 9″; the greater star is green, and the smaller bluish white. The image which this pair of stars presents is beautiful and well defined.

$\zeta$ of the 3d and 9th magnitudes; 12″ apart; greenish white and ash-coloured.

$\eta$ on the right side of the helmet; 4th and 8th magnitudes; distance 30″; the greater yellow, the smaller dark blue. Both colours very distinct.

$\theta$ 4th and 10th magnitudes; 15″ apart; the greater star is yellow. Proper motion among the other stars 37″ in a century.

By $\chi$, in the sword-hand of Perseus, a faint glimmer of light may be seen with the naked eye, which, when viewed through a telescope, appears as an extraordinarily rich collection of small and densely clustered stars. The whole group forms an ellipse, and has in its centre a double star.

On the left eye of Perseus we find another beautiful group of about 20 stars of the 8th, 9th and 10th magnitudes, with many other smaller stars. This group has also a double star at its centre.

### FABLE.

Perseus, the son of Jupiter by Danæ, undertook the perilous adventure of destroying the Gorgons, who were represented as three sisters. Of these, Medusa alone was mortal; and, though originally a person of great beauty, she had become

so disfigured by a metamorphosis of Minerva, that her beautiful locks were changed into snakes, and her face was so tremendous that all who beheld it were changed into rocks or stones. Perseus, however, favoured by the gods, succeeded in his undertaking, cut off Medusa's head, and afterwards rescued Andromeda from the sea-monster, by showing the latter the Gorgon's head, by which he was turned into stone. Perseus is represented with a sword in his right hand, Medusa's head in his left, and a sword at his ancles.

---

### Tarandus—*The Reindeer.*

*The Reindeer* was established by Lemonnier, in memory of the meridian measure completed in Lapland, in 1736. This constellation is situated between the middle of the Shepherd and the Pole-Star, and contains only small stars.

---

### Telescopium Herschelii—*Herschel's Telescope.*

This recent constellation lies between the Lynx and the Wagoner. It was proposed by P. Hell, in honour of Herschel and his discoveries in the heavens.

PLATE V.

CONSTELLATIONS.

| | |
|---|---|
| Pegasus . . . . | *The Flying Horse.* |
| Andromeda . . . | *Andromeda.* |
| Triangula . . . | *The Triangles.* |
| Musca . . . . . | *The Fly.* |
| Pisces . . . . . | *The Fishes.* |
| Aries . . . . . | *The Ram.* |

PEGASUS—*The Flying Horse.*

This constellation may be known by four stars, one of the 1st and the others of the 2d magnitude. They form a regular quadrangle, called the *Trapezium,* or sometimes the *Table.* The North-eastern of these four stars is in the head of Andromeda. They are:

α, *Markab.*
β, *Scheat.*
γ, *Algenib.*
α, *Sirrah,* (in the head of Andromeda).

Besides these we remark the following large stars:

| | |
|---|---|
| ε *Enif.* | θ *Baham.* |
| ξ *Homan.* | τ *Kerb.* |
| η *Matar.* | |

ε of the 3d magnitude, in the nose, is at a distance from α a little greater than the distance of α from γ, and nearly in a line with those two stars. η is also a star of the 3d magnitude, about 5° from

$\beta$ in the prolongation of the line through $\gamma$ and $\beta$. $\zeta$ is equally distant from $\varepsilon$ and $\eta$, the lines joining it with these two stars being nearly at right angles to each other.

$\varkappa$ is a double star. Its components are of the 4th and 11th magnitudes, 11″ apart, both yellow.

R. A. 320° 30′, Dec. 11° 26′, a large nebula, very bright in the middle, from which streaks of light proceed.

R. A. 327° 15′, Dec. 33° 30′, stands another light elliptical nebula, 30″ long and 9″ wide.

### FABLE.

Pegasus was a winged horse, which, as the mythologists pretend, sprang from the blood of Medusa when Perseus had cut off her head. He became the favourite of Apollo and the Muses; and being afterwards tamed, either by Neptune or Minerva, he was given to Bellerophon, when he undertook to conquer the Chimera. Having achieved this adventure, Bellerophon attempted to mount the heavens on his horse, but Jupiter sent a gad-fly to sting the animal, so that he dismounted his rider, who fell headlong to the earth. Pegasus, however, continued his flight upwards, and was placed by Jupiter among the constellations. The Jewish Rabbis have a legend of Nimrod, very similar to this of Bellerophon, which authorizes us to place this constellation among the oldest in the sphere.

## Andromeda, called also by the Arabs Phoca, *the Seal.*

This constellation lies between Pegasus, the Fishes, and Perseus. The three largest stars in it are:

$\alpha$ *Sirrah.*
$\beta$ *Mirach.*
$\gamma$ *Alamak.*

They stand nearly in a right line, which, prolonged above $\gamma$, would pass near Mirzak ($\alpha$ Persei). The other principal stars are $\delta$, $\varepsilon$ and $\pi$, midway between $\alpha$ and $\beta$; $\theta$ and $\zeta$, in the arms, forming nearly a square with $\alpha$ and $\beta$; and $\mu$ and $\nu$, in a line with $\beta$ perpendicular to the line joining $\gamma$ and $\delta$. All these are of the 4th magnitude except $\delta$, which is of the 3d.

The principal double stars are,

$\gamma$ or Alamak, which is seen double in common telescopes. Its components are of the 3d and 5th magnitudes; 10″ apart; orange-coloured and emerald green. The colours are very distinct; a beautiful object. See Plate XVI.

36 R. A. 11° 24′, Dec. 22° 41′; yellow; of the 6th and 7th magnitudes; $\frac{4}{5}$″ apart.

59 R. A. 30° 3′, Dec. 38° 13′; both bright yellow; of the 7th magnitude; distant 16″.

R. A. 16° 45′, Dec. 48° 5′, is a quadruple star of the 7th, 8th, 8th, and 11th magnitudes respectively, distant $\frac{1}{2}$″, 10″, and 30″.

R. A. 8° 15′, Dec. 40° 20′, Northeasterly over $\nu$ in the foot, is a remarkable nebula.

R. A. 9° 0′, Dec. 42° 57′, is a very wide-spread faint nebula, which embraces about eight square degrees.

R. A. 349° 30′, Dec. 41° 30′, is a round planetary nebula of 12″ diameter, with a whitish blue light, and in it is a fine double star.

FABLE.

ANDROMEDA, the daughter of Cepheus and Cassiopœia, was exposed to be devoured by a sea-monster, to appease the wrath of Neptune, but was rescued by Perseus, who made her his wife. After her death, Minerva changed her into a constellation. Andromeda is represented by the figure of a woman chained by the wrists to a rock. Some suppose the fable to be founded on the adventure of Jonah, who embarked at Joppa for Tarshish, to flee from the presence of the Lord, but, in consequence of a mighty tempest raised by his disobedience, was thrown into the sea and swallowed up by a great fish, from which he was afterwards miraculously delivered.

---

## TRIANGULA—*The Triangles,*

Lies between the head of Aries and the southern foot of Andromeda. It contains only smaller stars. The greatest among them is α or Mettallah. This is a recent constellation.

The principal double star is,

ι whose components are of the 5th and 6th magnitudes; 4″ apart; the greater is yellow, the smaller blue. This beautiful pair of stars is situated midway between α and δ. They may be seen in good telescopes with illuminated field.

## Musca—*The Fly.*

Between Aries and Perseus;—a small constellation, containing one star of the 3d and two of the 4th magnitudes.

---

## Pisces—*The Fishes.*

The two fishes are connected by a band; the one lies between Pegasus and Aquarius, and the other between Aries and the head of Andromeda. This constellation consists of stars of the 4th and inferior magnitudes.

Among the double stars are,

α Its components are of the 3d and 8th magnitudes; distant 5″; the greater greenish white, the smaller blue.

ζ of the 4th and 5th magnitudes; distant 23″; both white. Their proper motion is 11″ in a century.

♆ of the 5th magnitude; both white; distant 30″; easily seen in common telescopes.

R. A. 3° 0′, Dec. 14° 26′, a faint nebula, but extended over seven square degrees; and in R. A. 25° 0′, Dec. 5° 4′ is a star of the 8th magnitude, at the end of a fine, long, straight nebulous streak.

### FABLE.

These Fishes are said by the fabulists to be the same that Venus and her son Cupid transformed themselves into, to avoid the fury of the giant Typhœus, when he assailed the gods on the banks of the Euphrates. The character (♓) is supposed to have the appearance of two fishes tied back to

back; and the figure is that of two fishes tied by their tails, with a loose cord of some length.

The sun enters this sign about the 19th of February.

---

## Aries—*The Ram.*

We recognise this constellation by the three large stars in the head of the Ram, about 20 degrees due south of Alamak.

The principal stars are:

*α Hamel.*
*β Sheratan.*
*γ Mesarthius.*

Among the double stars are,

γ both of whose components are of the 4th magnitude; very white; distant 9″. See Plate XVI.

ε in the hinder part of the back; both white; of the 6th magnitude; distant half a second.

π in the middle of the thigh, is a triple star, of the 5th, 8th and 10th magnitudes; yellowish white; distant 3″ and 25″.

52 Arietis, R. A. 43° 48′, Dec. 24° 32′, is a triple star; the two largest are very white, of the 6th magnitude; distant $\frac{3}{4}$ of a second. The third is also very white, of the 11th magnitude; distant 5″ from the other two.

### FABLE.

The fabulists pretend that Aries was the ram which bore Phryxus and Hellé to Colchis, for the recovery of whose golden fleece Jason undertook the celebrated Argonautic expedition. The animal itself, say they, Jupiter snatched up to hea-

ven and formed into this constellation. The character (♈) by which it is marked, is supposed to represent the ram's horns. Among the ancient Egyptians, Ammon, the symbol of the sun in Aries, was represented with a disc over his head.

The sun enters this sign about the 20th of March, which constitutes the vernal equinox, the commencement of spring, and the beginning of the astronomical year. From this point the right ascension and longitude of the heavenly bodies are reckoned. It is the opening of the day at the North Pole, and the end of day at the South. The days and nights are also at this period equal all over the earth except at those points. The sun at this time has no declination, and is vertical to the equatorial parts of the earth.

---

## PLATE VI.

### CONSTELLATIONS.

| | |
|---|---|
| Auriga . . . . . | *The Charioteer.* |
| Taurus . . . . . | *The Bull.* |
| Cancer . . . . . | *The Crab.* |
| Orion . . . . . | *Orion.* |
| Gemini . . . . . | *The Twins.* |
| Monoceros . . . . | *The Unicorn.* |
| Canis Minor . . . | *The Little Dog.* |

---

### AURIGA—*The Charioteer,*

With his two Goats. In this we observe $\alpha$ or the *Goat* (*Capella* or *Alhajot*), a beautiful star of the first magnitude, and $\beta$ or *Meukalinam*, on the right shoulder. With these two stars, $\beta$, in the exterior right foot of the Charioteer, or at the extremity of the northern horn of the Bull, forms a triangle, by which the constellation may be easily recognised. Also, the three stars $\varepsilon$, $\zeta$ and $\eta$, form a small triangle.

Among the remarkable objects in this constellation are:

$\omega$ a double star. Its components are of the 4th and 8th magnitudes; distant 6″; the greater pomegranate colour, the smaller bluish white.

In R. A. 76° 2′, Dec. 32° 29′, is a triple star of the 5th, 7th and 11th magnitudes; distances 13″ and 15″; the greatest green, the two smaller bluish white.

R. A. 74° 15′, Dec. 37° 10′, stands a well-defined group of about 30 stars, with a double star in the centre.

R. A. 77° 0′, Dec. 39° 9′, is a rich group of stars, with an orange-coloured star in the centre.

R. A. 80° 0′, Dec. 34° 7′, is situated a nebula in the form of an isosceles triangle, the equal sides being 4″ in length, with a triple star at the centre of the triangle.

#### FABLE.

AURIGA.—Various accounts are given of the origin of this constellation. Some suppose Auriga to be the same as Phaëton, the son of Sol, who, undertaking to drive the chariot of the Sun, set the world on fire, and was struck by Jupiter into the Eridanus. Others identify him with Erichthonius, the Egyptian king of Athens, the reputed

inventor of chariots and the art of using them with horses. He is also represented as the same with Myrtilus, son of Mercury by Phaëtusa, and charioteer to Ænomaus, king of Pisa. He was famous for his great address in driving, and the management of horses; but his infidelity to his master cost him his life. He was, however, made a constellation after death, in compliment to his father, Mercury.

---

### Taurus—*The Bull.*

The most remarkable stars in this constellation are:

α *Aldebaran* or *Palilicium.*
β *Nath.*
γ *Hyadum I.*
δ *Hyadum II.*
ε *Ain.*

α is a star of the first magnitude in the right eye of the Bull; hence it is sometimes called the *Bull's Eye;* it may be known by its faint reddish light; β is in the extremity of the northern horn; γ is over the mouth, and ε in the left eye. In the end of the southern horn is the star ζ.

The stars α, γ, δ, ε and θ, form a figure like the letter V. This cluster of stars on the head of the Bull is called the *Hyades.* (See Pl. XVI. Fig. 13).

There is another group on the neck of the Bull, smaller but more dense than the former, called the *Pleiades* or *Seven Stars.* This is probably the

most remarkable and most generally known of all the groups in the heavens. It occupies a space about 2° in diameter, and contains one star of the 4th, six of the 5th, five of the 6th, and thirty-two of the 7th magnitude, besides many smaller ones. The most important of these stars are:

b *Electra.*
d *Merope.*
$\eta$ *Alcyone.*
f *Atlas.*

(See Pl. XVI. Fig. 12).

Six of these stars only are visible to the naked eye; but Pliny, Hipparchus, Ptolemy and others, reckoned seven. They pass vertically over the desert parts of Africa, Arabia, Bengal, the southern parts of China, California, and the Straits of Florida.

Among the double stars in the Pleiades, we notice:

$\eta$ or *Alcyone.* Its components are of the 4th and 7th magnitude; the greater is greenish white, the smaller white; distant 117″.

f or *Atlas*, of the 5th and 7th magnitudes; distant ½ second. This star appears double only in choice telescopes, in clear weather. The two stars appear to have a short period of revolution round each other.

n P'eiadum, of the 7th and 10th magnitudes; very white; distant 3″.

In R. A. 51° 2′, Dec. 23° 53′, is a triple star, 7 Tauri, of the 7th, 7th and 10th magnitudes, of a yellowish colour. The first two are two-thirds of a second apart, the third is distant 22″.

In R. A. 81° 0′, Dec. 21° 53′, is a beautiful elliptical nebula, 4′ long and 3′ wide.

FABLE.

TAURUS.—The ancient mythologists pretended that Taurus was the bull under whose form Jupiter concealed himself, when he carried off Europa from Tyre, across the seas to Crete; and that Jupiter rewarded the brute's service by making him a constellation. The character (♉) is said to represent the bull's face and horns.

THE PLEIADES, or *Seven Stars*, derive their name, according to the mythologists, from the seven daughters of Atlas and Pleione, who were changed into stars. Six of them had married immortal gods; but the seventh, Merope, married Sisyphus, a mortal, whence her light was dim and sometimes scarcely to be seen. The time of their rising, which is in the spring, was preferred by the ancients for undertaking long voyages.

The HYADES, in the south eye of Taurus, are, according to the mythologists, the seven daughters of Atlas and Æthra, and were metamorphosed into stars for immoderately bewailing the death of their brother Hyas, who had been devoured by a lion. The sun enters Taurus about the 20th of April.

---

CANCER—*The Crab*,

Contains but few important stars. The principal are:

α *Sertan*, or *Ezzaban*.
γ *The Northern Asellus*.
δ *The Southern Asellus*.

Between $\gamma$ and $\delta$ is *Præsepe*, or the *Manger*. This Manger (R. A. 127° 15′, Dec. 20° 30′) is a group of many stars clustered together. Upon a surface of about one-half a degree square, there are more than forty conspicuous stars, besides many other smaller ones. (See Pl. XVI., Fig. 14).

Among the double and multiple stars are,

$\zeta$ in the tail of the Crab; triple; components of the 5th, 6th and 6th magnitudes; all yellow. Distance of the first and second 1″, that of the third 5″. The first pair revolve round each other in 59 years, in an orbit nearly circular; their mean distance is 1″. The third revolves more slowly round the common centre of the other two. Or, more properly speaking, this system is composed of three suns, which all revolve round a common centre. This is the most remarkable system in the heavens.

$\iota^2$ is a double star, both of the 6th magnitude; distance $1\frac{1}{2}$″; the greater yellow, the smaller bluish.

In R. A. 129° 30′, Dec. 13° 13′, is a dense cluster of many small stars, in the middle of which there is a large central star.

### FABLE.

Cancer.—When Hercules, say the fabulists, was combating with the Lernæan Hydra, Juno, his inveterate enemy, sent a crab to bite him; the hero, however, crushed the reptile under his heel, and the goddess, out of compassion, placed it among the constellations. The character (♋), pointing both ways, is supposed to indicate the sun's declination from north to south; but it is more probably only a careless imitation of the old Egyptian and Hindoo mark ☋ for the Scarabeus,

or Beetle, which seems to have been the original sign of this constellation. The figure of a crab, which always moves sideways, is also fancied to be emblematical of the sun's motion when it enters Cancer, for it then passes sideways along the tropic without crossing it. Other figures, besides the crab, have been used for this constellation by the ancients; as the *beetle*, and Hermanubis, or Hermes with the head of an *ibis*, among the Egyptians; the *beetle*, in the Hindoo zodiac; and *two asses* by the Orientalists. The Greeks, through whom we have received the sign, placed two asses in it, where they still remain, under the titles of Asellus Boreas and Asellus Australis; and near them is the asterism Præsepe, or the Manger. The sun enters Cancer about the 21st of June.

## Orion.

This is the most beautiful constellation in the heavens. It was known in the most ancient times. It is mentioned by Job and by Homer. The principal stars are:

| | |
|---|---|
| α *Betelgeuse.* | δ *Mintaka.* |
| β *Rigel.* | ε *Anilam.* |
| γ *Bellatrix.* | ζ *Anitak.* |

α, or *Betelgeuse*, is on the right shoulder, β, or *Rigel*, is on the left foot, and γ on the left shoulder. Midway between α and β are the three stars in the girdle; δ, or *Mintaka*, ε, or *Anilam*, and ζ, or *Anitak*, standing in a right line, and forming

*Jacob's Staff*, or the *Three Kings*, as they are called by some; they are also by some denominated the *Rake*. $\varkappa$ forms with $\alpha$, $\gamma$ and $\beta$, a large quadrilateral figure, with Jacob's Staff in its centre. Below the three stars in the girdle are $\eta$ and $\iota$, and several smaller stars, forming the sword. A little above the line, joining the stars in the shoulders, are three small stars in the head of Orion. East of Bellatrix are several small stars in Orion's shield, forming a curve, concave towards his head.

South of $\zeta$, the lowest of the three stars in the girdle, is $\sigma$, which Schröter considered twelve-fold, but Struve, with the Dorpat Refractor, has found to be sixteen-fold. Under $\sigma$, in a right line with $\zeta$ and $\sigma$, near $\theta$, is found the great and remarkable nebula; and in the densest part of this nebula appears the star $\theta$ itself, as a sextuple star, of which, however, only 4 stars, forming a trapezium, can be seen in ordinary telescopes. A fifth star, of the 11th magnitude, was discovered by Struve, in 1826. This small star can be seen in the 9 feet Fraunhofer Refractor of the High School, at Philadelphia. A 6th star, of the 12th magnitude, has since been discovered. It was too faint to be measured in the Dorpat Refractor; but in the great Pulkovah Refractor its place is readily measured, with the field of the telescope illuminated.

By comparison of the recent drawings of this nebula with the more ancient, it appears that it is continually changing its appearance. Perhaps it is undergoing the process of condensation, sup-

posed by some astronomers to take place in the formation of stars and stellar systems!

Among the double stars we also remark,

β or Rigel; its components are of the 1st and 8th magnitudes; distant 10″; colour yellowish white. See Plate XVI.

ζ in Jacob's Staff, of the 2d and 6th magnitudes; distant 2″; the greater yellowish white, the smaller reddish green.

ι of the 3d and 7th magnitudes; distant 11″; the greater yellowish white, the smaller blue.

λ is a triple star, of the 4th, 6th and 12th magnitudes; distances 4″, and 27″; the greatest yellowish, the smaller purple.

ς of the 5th and 8th magnitudes; distant 7″; yellow and blue.

In R. A. 82° 0′, Dec. 1° 19′, near ε, and southward from it, is a beautiful star, in a very large round nebula of 24′ diameter.

This constellation abounds in nebulous stars, which are quite variable in their nebulosity. Herschel, the elder, attributes this change to the changes that seem to be going on in the nebulæ in Orion, which he thinks are situated on this side of the stars, and cause their nebulous appearance.

### FABLE.

Orion was a celebrated hero of antiquity, and a mighty hunter, who accompanied Diana and Latona to the chase, but perished by the bite of a scorpion for his improper conduct. Being, however, a descendant of the gods, Jupiter made him a constellation; and he is represented with a

sword in his belt, a lion's skin upon his left arm as a shield, and a club in his right hand. He seems to be the representative of Nimrod, that "mighty hunter," who is supposed to have been the author of the postdiluvian heresy.

---

## GEMINI—*The Twins.*

This constellation is readily distinguished by the two stars,

$\alpha$, or *Castor.*

$\beta$, or *Pollux.*

A line drawn from $\beta$ through $\alpha$ of Orion, and prolonged north-east of $\alpha$ to nearly twice the distance of these two stars, will terminate near $\beta$ in the head of Pollux. Below, and near this line, lie $\gamma$, $\zeta$ and $\delta$, three stars of the 3d magnitude, of which the first is in the foot, the second in the thigh, and the third in the girdle of Pollux. About $4\frac{1}{2}°$ north-west of *Pollux*, is $\alpha$ or *Castor*, in the head of Castor. A line drawn through $\alpha$, parallel to the former line, would pass through $\varepsilon$ in the knee, and just below $\mu$ in the foot of Castor; these two stars are also of the 3d magnitude. Besides the seven principal stars above-mentioned, there are a great many smaller ones, which may be found by means of their positions with reference to the above and to each other.

Among the double stars are,

α or Castor; its components are of the 3d and 4th magnitudes; both greenish; distant 5″. The stars of this remarkable and beautiful pair revolve round each other in 232 years; their mean distance is 7″. They may be seen double in a good three feet telescope; they have both the same proper motion among the other stars of 119″ in a century. See Plate XVI.

δ of the 3d and 8th magnitudes; distant 7″; the greater yellowish, the smaller purplish.

τ of the 3d and 10th magnitudes; distant 10″; the greater bluish green.

In R. A. 108° 45′, Dec. 29° 50′, stand two spherical nebulæ of equal magnitudes, with their limbs in contact, each having a bright nucleus in the centre.

In R. A. 109° 46′, Dec. 21° 15′, is a star of the 8th magnitude, in the centre of a round, light nebula, of 25″ diameter.

FABLE.

GEMINI.—The mythologists pretend that Castor was the son of Jupiter and Leda; and that between him and his half-brother Pollux immortality was alternately shared. The character of this sign (♊) is two perpendicular lines, joined at top and bottom by two parallel lines, indicative of union. The figure has long been that of two boys; but it has had other devices, as two goats, &c. The sun enters Gemini about the 21st of May.

---

## MONOCEROS—*The Unicorn.*

This constellation was introduced by Hevelius. It occupies a considerable space south of the

Twins and the Little Dog, and east of Orion. It contains only four stars of the 4th magnitude, and some others still smaller, and is not very easily traced in the heavens.

In R. A. 95° 5′, Dec. south 6° 55′, is a triple star, whose components are of the 5th, 5th and 6th magnitudes; distant 2″ and 7″; all white.

---

## Canis Minor—*The Little Dog.*

This constellation is distinguished by two large stars,

*α Procyon,*
*β Mirza* or *Gomeiza,*

which lie about 20° south of Castor and Pollux. Procyon is a very bright star of the 1st magnitude: it forms, with *β* and *γ* of the Twins, a triangle very nearly equilateral.

### FABLE.

Canis Minor.—This constellation is feigned to have been a hound of Orion by the Greeks; or, according to some, it was Mæra, who, by his cries, showed Erigone where her murdered father had been thrown — then pined away, but was made a constellation. The Egyptians were probably the inventors of this constellation; and they may have given it this figure to express a little dog, or watchful animal, going before or leading on the greater, or rising before it; and hence the Latins called it *Antecanis,* the star before the dog.

---

PLATE VII.

CONSTELLATIONS.

| | |
|---|---|
| Boötes . . . . . | *The Herdsman.* |
| Lyra . . . . . | *The Harp.* |
| Hercules . . . . | *Hercules.* |
| Corona Borealis . . | *The Northern Crown.* |
| Taurus Poniatowski | *The Polish Bull.* |

## Bootes—*The Herdsman.*

This is a large constellation, south of the Great Bear, and between the Heart of Charles and the Northern Crown. The principal stars are:

| | |
|---|---|
| $\alpha$ *Arcturus.* | $\eta$ *Mufried.* |
| $\beta$ *Nekkar.* | $\mu$ *Alkalurops.* |
| $\varepsilon$ *Izar.* | |

Arcturus is a bright star of the 1st magnitude, and may be found by conceiving the curve which passes through the three stars in the tail of the Great Bear to be continued about 30° from $\eta$. On the opposite sides of Arcturus, and nearly in a line with it, are two stars, $\eta$ and $\xi$, of the 3d magnitude, in the legs. 6° east of $\eta$ of the Great Bear, is $\theta$ in the left hand. A line drawn through $\delta$ and $\eta$ of the Great Bear, and produced twice their distance beyond $\eta$, would terminate near $\gamma$ in the left shoulder; and about 6° east of this star will be found $\beta$ in the head of Bootes. About 8° below $\beta$, and in a line with $\theta$, is $\delta$ in the right shoulder.

$\gamma$, $\beta$ and $\delta$, form a triangle, right angled at $\beta$. In a line with $\delta$ and Arcturus, and midway between them, is $\varepsilon$ in the belt.

The principal double stars in this constellation are:

$\varepsilon$ in the girdle. Its components are of the 3d and 6th magnitudes; distant 4″; the greater deep yellow, and the smaller bluish green. It requires a good telescope to show $\varepsilon$ as a double star.

$\zeta$ not far from $\pi$; 4th magnitude; distant $1\frac{1}{5}$″; both white.

$\iota$ a triple star, of the 6th, 6th and 7th magnitudes; the two greater distant $\frac{1}{4}$ of a second, the smaller distant 38″.

$\chi$ on the left hand; 5th and 8th magnitudes; distant 13″; the greater white, the smaller reddish blue.

$\pi$ on the right calf; 5th and 6th magnitudes; distant 7″; both very white.

$\xi$ in the right knee; 5th and 7th magnitudes; distant 9′; the greater yellow, the smaller purple. They revolve about each other in a period of 120 years.

We find, moreover, in this constellation, the following objects:

In R. A. 196° 0′, Dec. 19° 4′, a beautiful, round group of stars, of 5′ diameter, which, in the middle, is very bright.

In R. A. 209° 30′, Dec. 29° 20′, a large, round, very rich group, of 10′ diameter, without a light nucleus.

In R. A. 224° 45′, Dec. 19° 6′, a very large, round, planetary nebula, of 6′ diameter: and

In R. A. 225° 0′, Dec. 20° 32′, two equal, oval nebulæ, nearly touching each other.

### FABLE.

Some suppose Bootes to be the same with Icarus, the father of Erigone, who was killed by shepherds for inebriating them. Others maintain that, before his translation, he was Arcos, the son

of Jupiter and Calisto; others, that he was Lycaon, the father of Calisto; and some hold him to be the same with Erichthonius, the inventor of chariots and the method of harnessing horses to them. This, however, confounds him with Auriga. The fact is, these are all ideal personages; and the origin of this constellation seems to be lost in antiquity. Bootes is represented as in a walking attitude, grasping in his right hand a spear, while in his left, extended upwards, he holds the last of the dogs Asterion and Chara, which seem to be barking at the Great Bear.

---

## Lyra—*The Harp.*

This small, but beautiful constellation, lies in one of the regions richest in stars of all the heavens, where also the milky-way is very bright. $\alpha$ or *Vega*, also called *Lucida Lyræ*, is one of the largest and most beautiful of the fixed stars. The other large stars are $\beta$ or *Sheliac*, and $\gamma$ or *Sulaphat*. This constellation lies south-east of the head of the Dragon, and west of the neck of the Swan. Vega forms, with two small stars, $\varepsilon$ and $\zeta$, an equilateral triangle. $\beta$, $\gamma$ and $\delta$, may be easily recognised in the heavens by an inspection of the map.

Among the double and multiple stars are the following:

$\alpha$ Its principal component is of the 1st magnitude. It has a very small companion of the 11th magnitude placed at a distance of 42″. (See Pl. XVI. Fig. 11.) This system is distant from our sun 771,400 times the earth's mean distance. Its light reaches us in 12 years.

$\beta$ is a quadruple star, or two pairs of stars, standing near each other. Both pairs may be seen in the same field of the telescope. The stars are of the 3d, 7th and 9th magnitudes, and the greatest $\beta$ is changeable in its light. It diminishes in $6\frac{1}{2}$ days from the 3d to the 5th magnitude, and then increases again to the 3d.

$\varepsilon$ over Vega; 5th and 6th magnitudes; distant $3''$; the greater greenish white, the smaller bluish white. Near this also is a second double star, visible in the same field of the telescope, both white, of the 5th magnitude, distant $2\frac{1}{2}''$. Both these pairs of stars have the same proper motion of $8''$ in a century.

$\zeta$ on the left of Vega and near it; 4th and 5th magnitudes; distant $44''$; both greenish white. This star appears double with ordinary telescopes.

$\eta$ on the left side of the Harp; 4th and 8th magnitudes; distant $28''$; the greater blue, the smaller ash-coloured.

In this constellation we also find,

In R. A. 287° 30′, Dec. 29° 53′, a beautiful group or cluster of stars, nearly in the figure of a triangle, without any proper nucleus. The greatest diameter of the triangle is 3′:

In R. A. 281° 45′, Dec. 32° 49′, between $\beta$ and $\gamma$, a very remarkable annular nebula, whose exterior diameter is $6\frac{1}{2}''$. (See Plate XVIII. Fig. 48).

### FABLE.

Lyra. — This celestial lyre is said to be the same which Apollo gave to Orpheus, when the latter descended to Pluto's dominions to redeem his bride Euridice from death; and after his own decease, it was made a constellation. It is with much greater propriety supposed to be an emblem of the very ancient doctrine of the musical harmony of the spheres, which still prevails in the East.

HERCULES ET CERBERUS—*Hercules with the Cerberus.*

In this constellation we observe $\alpha$ or *Ras Algethi*, on the head; $\omega$ or *Kajam*, on the right elbow; and $\lambda$ or *Masini*, in the upper part of the left arm:—$\alpha$ in the head, $\delta$ in the breast, and $\pi$ in the leg, are equidistant, and in a right line, which produced would pass through the North Pole. Extending from $\delta$ towards $\gamma$ in the Harp, is a line of several small stars in the left arm, and below this arm are several small stars in the Cerberus. The star $\zeta$ forms a nearly equilateral triangle with $\delta$ and $\pi$, and near the centre of this triangle is $\varepsilon$. About midway between Ras Algethi and the Northern Crown, is $\beta$; and 2° south-west of $\beta$ is $\gamma$. These stars are chiefly of the 3d magnitude. Several others of the 3d and 4th magnitudes may readily be traced by a reference to the map.

Among the remarkable double stars of this constellation, are found

$\alpha$ Its components are of the 3d and 7th magnitudes; distant 5″; deep yellow, and deep blue. The greater changes from the 3d to the 4th magnitude in 60 days. (See Pl. XVI.)

$\delta$ of the 3d and 8th magnitudes; 25″ apart; the greater green, the smaller ash-white.

$\zeta$ of the 3d and 6th magnitudes; distant 1″; the greater yellowish, the smaller purplish. They revolve round each other in 31 years, at a mean distance of 1½ seconds.

$\varkappa$ of the 5th and 6th magnitudes; distant 31″; both yellow; easily seen in common telescopes.

$\mu$ of the 4th and 10th magnitudes; yellow; 30″ apart. The

proper motion of these two stars among the other stars, is 82″ in a century.

ζ of the 4th and 5th magnitudes; distant 4″; greenish white, and green.

In R. A. 248° 45′, Dec. 36° 48′, between ζ and η, is a very rich group of stars of an irregular form, without nucleus.

This is the constellation towards which our sun with all its planets and their satellites, is moving in absolute space. The elder Herschel first conceived the idea of explaining the proper motions of the stars by such a supposition. He chose for the point of direction the star λ. Herschel's opinion was doubted by many astronomers; but was finally shown to be correct by Argelander. It is now ascertained that our system is moving towards a point in R. A. 259°, Dec. 35°, which is about a degree north-east of the small star u Herculis, being within 10° of the point first conjectured by Herschel. The velocity of our system in this direction is estimated, by Struve, to be about half as great as that of our earth in its orbit, or about 8 miles per second.

### FABLE.

Hercules, who is represented in this plate as kneeling, with the skin of the Lernæan lion thrown over his shoulders, holding a club in his right hand, and Cerberus in the left, was a celebrated hero of the most remote antiquity, and one of the great gods of the Egyptians. Many persons are said to have borne the name; but all their exploits are attributed to the Theban Hercules, the reputed son of

Jupiter and Alcmene. Of his numerous achievements, twelve are more particularly noticed as the *Twelve Labours* of Hercules, and are supposed to be emblematic of the sun's progress through the twelve signs of the zodiac. The name is a corruption of *Arcles*, a title of the sun.

Cerberus, according to Hesiod, was a dog with a hundred heads, though our mythologists give him only three; he was reputed to belong to Pluto, and to be stationed at the gates of the infernal regions as a guard. Cerberus is represented in the plate as a three-headed serpent. From this situation, Hercules, as his concluding labour, dragged him up to the realms of day, when he went to redeem Alceste. Some suppose this to be an astronomical fable, relating to the sun on his arrival at the autumnal equinox.

---

Corona Borealis—*The Northern Crown.*

This beautiful little constellation is situated between Bootes and Hercules. The two largest stars of this constellation are $\alpha$, or *Gemma*, the
ι Jewel, and $\beta$, or *Nusakan*. This constellation may be easily recognised by the regular curve
ζ formed by the principal stars.

The principal double stars are,

γ Its components are of the 4th and 7th magnitudes; dis-
χ tance, in 1826, $\frac{7}{10}''$, in 1833, $\frac{4}{10}''$, in 1841, $\frac{1}{5}''$, in 1842, round and single; the greater greenish white, the smaller purple.
μ ζ of the 4th and 5th magnitudes; distant 7″; the greater greenish white, the smaller greenish.

η of the 5th and 6th magnitudes; distant 1″; both yellow. They revolve round each other in 43 years. Their proper motion among the stars is 22″ in a century.

δ of the 5th and 6th magnitudes; distant 1″. They revolve round each other in 608 years, and their mean distance is 4″. Their doubleness can only be detected by good telescopes. They have both the same proper motion of 31″ in a century.

In R. A. 227° 44′, Dec. 27° 30′, are two very white stars, of the 6th magnitude; distant $1\frac{8}{10}$″.

υ a triple star, of the 7th, 9th and 10th magnitudes; distances 89″, and 126″.

In R. A. 235° 5′, Dec. 28° 47′, over δ, is a changeable star, which, in the period of 335 days, from being of the 6th magnitude, entirely disappears, and again increases to the 5th.

FABLE.

Corona Borealis.—This crown has the reputation of being the same which Bacchus gave to Ariadne, the daughter of Minos; and after her death it was made a constellation; from Gnossus, a city of Crete, and the residence of Minos, it has obtained the name of the *Gnossian Crown*. By the Hebrews this asterism was called *Ataroth*, which is still its name in the East.

---

Taurus Poniatowski—*The Polish Bull*,

Is between the head of Hercules and Lyra, was introduced in the year 1778, by the Polish astronomer Poczubut, in honour of the King of Poland, and contains only stars of the 4th and smaller magnitudes.

## PLATE VIII.

### CONSTELLATIONS.

| | |
|---|---|
| Leo Major . . . | *The Great Lion.* |
| Virgo . . . . | *The Virgin.* |
| Coma Berenices . | *Berenice's Hair.* |
| Sextans . . . . | *The Sextant.* |

### Leo Major—*The Great Lion.*

The principal stars in this constellation are:

$\alpha$, or *Regulus.*
$\beta$, or *Denebola.*
$\gamma$, or *Algieba.*
$\delta$, or *Zosma,* also *Hur el Asad.*
$\varepsilon$, or the southern *Ras el Asad.*
$\mu$, or the northern *Ras el Asad.*
$\varkappa$, or *Minchir.*
$o$, or *Coxa,* also called *Lubra.*

A line drawn from $\delta$ through $\gamma$ of the Great Bear, will point to Regulus, in the breast, sometimes called the *Lion's Heart,* and would also pass through $\gamma$, in the neck of the Lion. $\eta$ below $\gamma$, and $\gamma$, $\zeta$, $\mu$ and $\varepsilon$, form a curve in the head and neck; and these, with Regulus, constitute a figure somewhat like a sickle, Regulus and $\eta$ forming the handle. In a line with Regulus and Arcturus, will be found $\beta$, or Denebola, a star of the 2d magnitude, in the tail of the Lion. Nearly in a line with $\beta$ and $\gamma$ is $\theta$; and 5° due north of $\theta$ is $\delta$; and a line drawn from $\delta$ through $\theta$, would point out several smaller stars in the hinder legs.

Of the most conspicuous double stars of this constellation we remark:

γ the most splendid double star in the northern hemisphere, whose components are of the 2d and 4th magnitudes; distant 3″; the greater gold yellow, the smaller greenish purple. Both stars have the same proper motion of 31″ in a century among the other stars. (See Plate XVI. Fig. 5.)

ι of the 4th and 7th magnitudes; distant 2″; the greater yellowish, the smaller blue.

ω on the fore-paw; of the 5th and 7th magnitudes; both yellow. They revolve round each other in 83 years, and their mean distance is $\frac{4}{5}''$. In 1841, their distance was $\frac{3}{10}''$; since then, in 1842 and 1843, they have appeared as a single round star.

In R. A. 116° 30′, Dec. 25° 42′, there is a beautiful, well-defined double star, of the 5th and 7th magnitudes; distant 7″.

In R. A. 144° 12′, Dec. 12° 21′, between the fore-paws, is a variable star, which, in a period of 311 days, fades from the 5th magnitude and disappears, and again reappears and increases to the 5th magnitude.

The most remarkable nebulæ of this constellation are:

In R. A. 167° 30′, Dec. 14° 0′, a light round nebula, growing brighter toward the middle, with a decided nucleus.

In R. A. 140° 30′, Dec. 22° 15′, a double nebula. Both nebulæ together form an elliptic figure, of which the major axis is 3′.

In R. A. 167° 45′, Dec. 14° 32′, a nebulous streak 15′ in length and 1′ in width, brighter toward the middle, with a fine star.

There is, also, in R. A. 181° 45′, Dec. 14° 6′, a nearly similar, though smaller nebula.

### FABLE.

Leo.—This sign is supposed by the fabulists to be a metamorphosis of the Nemæan lion, which

Hercules slew. The character (♌) represents the tail of that animal in an agitated state. In the Egyptian calendar, the sign Leo contains the figures of two lions, and the head of a third.

The sun enters this sign about the 23d of July. It is chiefly situated north of the ecliptic, and passes over the countries situated in the north part of the torrid zone, where lions are generally found.

---

## Virgo—*The Virgin.*

α or *Spica, the Ear of Corn,* or *Azimech.*
β or *Savijava.*
ε or *Vindemiatrix.*
η or *Zaniah.*

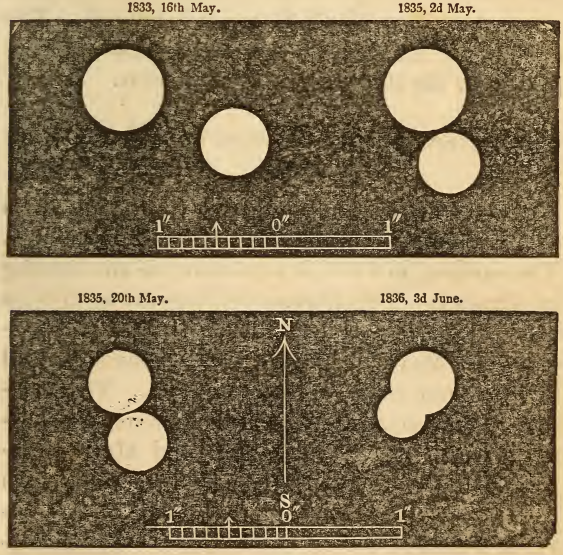
Spica is a beautiful star of the 1st magnitude, and may be easily distinguished by its brilliancy, being the only conspicuous star in the neighbourhood. A line drawn from β in the head of Bootes through Arcturus, will point it out. Spica, Arcturus, and β in the tail of the Lion, form a very nearly equilateral triangle, the sides of which are each about 40°. A line drawn from Arcturus between η and υ of Bootes, will point out ε in the northern, and β in the southern wing of the Virgin. A line drawn from β to a point about 5° north of Spica, will pass η, γ and θ, all in the southern wing; this line continued, will show us κ and λ in the southern foot. A little north of these last we find μ in the northern foot, and φ and ι in the robe. Between ε and γ is δ in the

waist. The head is marked by four small stars between $\beta$ Virginis and $\beta$ in the tail of the Lion.

---

### The Stellar System $\gamma$ Virginis.

The appearance of the two components of this system in the Dorpat telescope, is shown in the cuts. Both are of the 3d magnitude, of a yellowish colour.

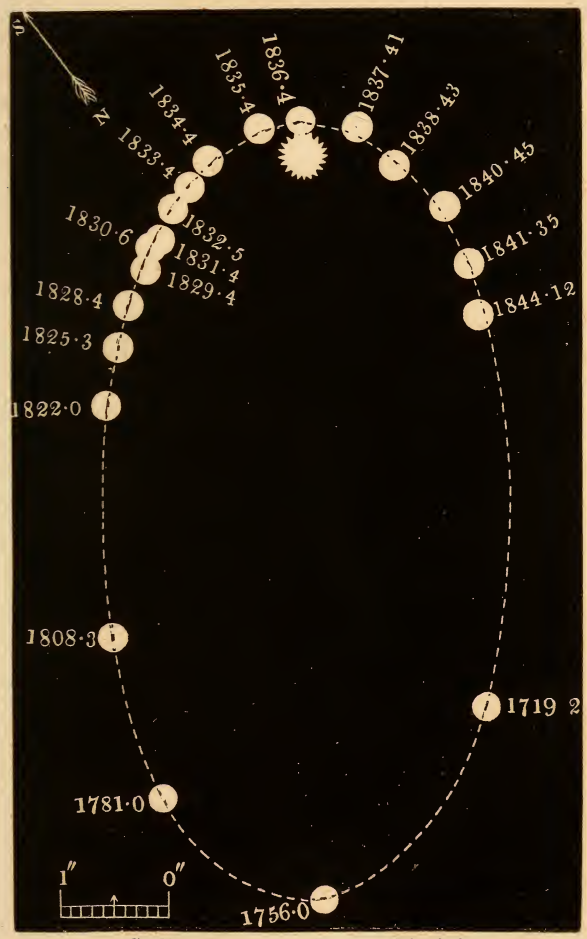



This drawing is for an inverting telescope, magnifying the distance 1000 times. The upper star in the figure is variable in size compared

with the other. Sometimes it is larger, sometimes it is smaller. Mr. Mædler explains this variation by supposing that one of them, though apparently single in the best telescopes, is really a double star, forming in this way a triple system. A pair of stars so close to each other in this system must, according to Kepler's third law, "that the squares of the periodical times are as the cubes of the mean distances," revolve rapidly round each other, and cause a change in the apparent size perhaps as great as that which Struve has noticed. The disturbance of the two bodies by their near approach to the third, must be very great.

### EXPLANATION OF THE DRAWING OF THE APPARENT ORBIT.

Mædler has collected together all the measures of the bearing and distance of the components. The earliest, in 1719, is a measure of the bearing by Bradley. The distance by Cassini, in 1721, is only a vague estimate. The bearings and distances by Mayer in 1756, and the elder Herschel in 1781 and 1803, are more precise. The measures made since 1825 with the Fraunhofer filar-micrometer, chiefly by Struve and Mædler, exhibit great perfection, and conform well with each other. That of 1844, was made in February, at the High School observatory. These measures are all represented in the drawing. Bradley's, Mayer's, and the elder Herschel's bearings, are retained. Cassini's distance has been dimin-




Stellar System. Gamma Virginis.

ished about a second, and applied to Bradley's bearing. The distances of Mayer and the elder Herschel have been slightly modified, so as to conform to the most natural curve. This apparent curve is an ellipse, the plane of which is perpendicular to the line of direction, leading from the observer to this stellar system. The true orbit is inclined to this apparent orbit, and, of course, is here seen in perspective.

The earliest computation of the orbit of these two stars was made about 15 years since, by Sir John Herschel, before their passage of their perihelion. The imperfection of the measures then available, was such as to lead to an orbit with a period of 560 years. Shortly after the perihelion passage, and the opening of the stars in 1838, Mr. E. P. Mason, of Yale College, obtained an orbit with a period of 171 years. Mædler, from the most recent measures compared with all the preceding, finds an orbit for these two components, having a period of $145\frac{2}{3}$ years. According to him, they revolve round each other in an elliptic orbit, having for the longer axis $6.\frac{3}{10}''$, and for the shorter only $\frac{3}{10}$ of a second. The history of this stellar system extends back 125 years, in which period they have nearly completed their orbit, having passed their greatest distance or *aphelion* in 1763, and their *perihelion* or nearest approach in 1836.

At this time the components were so close that no telescope in the world could separate them.

Their appearance, when magnified a thousand times in the Dorpat telescope, is shown above. In the spring of 1836, their angular motion was a degree in 5 days. Such a velocity was required in order that, according to Kepler's second law, their radius vector, or the line joining them, should sweep through the same area in a day as when at their greatest distance in 1763.

This remarkable stellar system promises to afford a deep insight into the secret workings of nature. The orbit of Mædler was computed simply on Kepler's hypothesis of an ellipse, in which equal areas are described in equal times.

If the force which causes this motion is that of Newtonian, or universal gravitation; then the actual velocity of each component in its orbit must increase as the square of their observed distance, or radius vector, diminishes. Mædler having computed their orbit without the latter supposition, found that the employment of it would cause no sensible change in the result; a beautiful confirmation this of the doctrine of the *universality* of Newtonian gravitation!

The components of this system, besides their orbital motion caused by some original projectile force, and their mutual attractions, have also the same proper motion of 52″ in a century, among the other stars. This affords a farther proof that they are bound together by some force different from that which connects them with the stars that appear in their vicinity.

Their distance will increase for the rest of the 19th century. In the latter portion of it they will be easily seen double in ordinary telescopes. At present their distance is 2″. They appear elongated in the 9 feet telescope of the High School Observatory, with a power of 100. With a power of 500, they appear to be separated by an interval five times as great as the diameter of the disc of either.

The other principal double stars are,

$\theta$ at the left of $\gamma$; its components are of the 4th and 9th magnitudes; distant 7″; both white.

$\phi$ of the 5th and 10th magnitudes; yellow; distant 4″.

In R. A. 213° 30′, Dec. 9° 13′; of the 5th and 7th magnitudes; distant 6″; the greater bluish white, the smaller greenish white.

The star in R. A. 187° 5′, Dec. 8° 5′, on the right wing of the Virgin, is variable. In the period of 145 days it varies from the 6th magnitude to invisibility, and increases again to the 6th.

In R. A. 181° 15′, Dec. 15° 51′, is found a narrow nebula, nearly 10′ in length, irregular at one end, with a nucleus like a bright star in the middle.

In R. A. 154° 0′, Dec. 5° 53′, there is a star of the 8th magnitude, with a spherical, bright atmosphere, which is visible with moderate telescopes.

In R. A. 193° 0′, Dec. 3° 25′, a star of the 8th magnitude, on one side of which hangs a small oval nebula.

In R. A. 187° 45′, Dec. 10° 40′, south; a bright, oval nebula, 5′ long, and $\frac{1}{2}$′ wide, with a light nucleus.

### FABLE.

Virgo.—This constellation, among the mythologists, was Astræa, the goddess of Justice, who dwelt upon earth during the golden age, but was

translated to heaven when men gave themselves up to wickedness. Originally the character of this sign (♍) consisted of three ears of corn; the figure is that of a virgin, with a stern but majestic countenance, and winged, holding a pair of scales in one hand and a sword in the other; or with a palm-branch in one hand and some ears of corn in the other. Among the Egyptians, Virgo was the goddess Isis; in the Oriental zodiacs, she is represented as a mother; the Arabian and Syrian astronomers describe her with a male infant in her arms; and in the Persian sphere she also nurses a boy. The sun enters the Virgin about the 23d of August.

---

### Coma Berenices—*Berenice's Locks.*

This is a cluster of small stars about midway between Denobola, in the Lion, and α, or Charles' Heart, in the Hounds. It contains five stars of the 4th magnitude, with many smaller ones. Its appearance to the naked eye is the same as that of a *resolvable nebula* in a good telescope.

The cut shows the appearance of 42 Berenice's Locks in the Dorpat telescope, with a magnifying power of 1000.

This pair is situated in R. A. 195° 24′, Dec. 18° 28′; both yellow; of the 6th magnitude. In 1827 they were distant $\frac{1}{2}''$; in 1841, $\frac{1}{3}''$; in 1843 they appeared single and round. They have both the same proper motion among the stars, 45″ in a century.

The principal double stars are,

In R. A. 178° 45′, Dec. 22° 26′, at the right of the star h, is a double star, whose components are both of the 7th magnitude; distant 4″; having a beautiful well-defined image.

In R. A. 186° 30′, Dec. 19° 21′, near the star l, of the 5th and 6th magnitudes; distant 21″; the greater yellow, the smaller blue.

In R. A. 191° 12′, Dec. 22° 11′, there is a triple star of the 5th, 8th and 9th magnitudes; the greatest yellowish, the middle-sized blue; distances $1\frac{1}{2}''$ and 29″.

In R. A. 186° 8′ Dec. 22° 9′, is a pair of stars of the 8th and 9th magnitudes. In 1827, they were $\frac{4}{5}''$ apart; in 1841, they appeared single and round; in 1842, they were again parted to the distance of $\frac{1}{2}''$.

In R. A. 187° 0′, Dec. 12° 8′, is seen a very beautiful double nebula; both nebulæ bright, rounded, and lighter toward the centre. Their diameters are 45″ and 60″.

In R. A. 192° 0′, Dec. 22° 37′, lies a double star enclosed by a bright, round nebula, whose diameter is nearly 6′.

In R. A. 187° 0′, Dec. 26° 56′, we find a nebulous streak, 15′ in length and $\frac{1}{2}'$ wide, with a faint nucleus, and in the middle of it a star of the 9th magnitude. Parallel to this nebula and near to it, another similar, but smaller nebula is visible.

In R. A. 196° 0′, Dec. 19° 4′, between the stars r and v, appears a very rich and dense cluster of stars, of the 10th and 12th magnitudes. The diameter of the cluster is 5′.

FABLE.

Coma Berenices.—When Ptolemy Euergetes, king of Egypt, was going on a dangerous expedition to Syria, about B. C. 247, his queen, Berenice, dedicated her hair to Venus, and hung it up in the temple. Sometime after the return of Euergetes, the tresses were missing; and Conon of Samos, a great astronomer of his time, declared that Jupiter had transferred them to the heavens in the form of this constellation.

---

Sextans—*The Sextant.*

This was instituted by Hevelius, and contains only small stars. It is situated between the Great Lion and the Water Serpent.

---

PLATE IX.

CONSTELLATIONS.

| | |
|---|---|
| Antinoüs | *Antinoüs.* |
| Aquila | *The Eagle.* |
| Libra | *The Scales.* |
| Serpens | *The Serpent.* |
| Delphinus | *The Dolphin.* |
| Equüleus | *The Little Horse.* |
| Scutum Sobieski | *Sobieski's Shield.* |
| Turdus Solitarius | *The Solitary Thrush.* |
| Vulpecula et Anser | *The Fox and Goose.* |
| Sagitta | *The Arrow.* |

### ANTINOÜS—*Antinoüs.*

This small constellation under the *Eagle* was instituted by Tycho Brahe. It contains two stars of the 3d and four of the 4th magnitude, which may be found on referring to the map, by means of the stars in the *Eagle.*

$\eta$ in the left arm, is variable. It changes in $7\frac{1}{3}$ days from the 4th to the 5th magnitude.

In R. A. 301° 30′, Dec. 4° 2′, south, is a double star, of the 6th and 8th magnitudes; distant 14″.

---

### AQUILA—*The Eagle.*

The Eagle is situated south of the *Swan.* The principal stars are:

| | |
|---|---|
| $\alpha$ *Altair.* | $\gamma$ *Tarazed.* |
| $\beta$ *Alschain.* | $\zeta$ *Dscheneb Okab.* |

This constellation may be readily found by the three stars $\alpha$, $\beta$ and $\gamma$, placed in a line, the bright star $\alpha$ being midway between the other two. The two stars $\zeta$ and $\varepsilon$ will be found midway between Altair and the Cerberus (in the hand of Hercules). In the southern wing, south-west of $\gamma$, are the two stars $\mu$ and $\delta$.

Among the double stars we notice,

$\pi$ about 2° N. E. of $\gamma$; its components are of the 6th and 7th magnitudes; distant 1″. Both stars are yellow.

$\varkappa$ of the 6th and 7th magnitudes; distant 1″; lately discovered by Struve, at the Pulkovah Observatory.

In R. A. 290° 45′, Dec. 8° 53′, there is a round, very rich group of stars, 40″ in diameter.

---

## Libra—*The Scales.*

The *Scales* lie east of the Virgin. The principal stars are:

α *Zuben el Genubi.*
β *Zuben es Chimali.*
γ *Zuben el Akrab.*

α in the southern scale, may be found by continuing the line of the stars in the southern wing and foot of the Virgin. β is north-east of α, and about 9° distant from it. β, Arcturus and Spica, form a triangle nearly equilateral. The other stars may be found, by referring to the map, without much difficulty.

The star ξ is triple; of the 5th, 5th and 7th magnitudes; distant 1″ and 7″; the two greatest yellowish white, the smallest bluish white.

In R. A. 270° 30′, Dec. 2° 44′, is a beautiful, dense cluster of stars, whose centre is very bright.

### FABLE.

This sign constitutes the balance of Astræa, and its character (♎) is supposed to represent the beam. The Greeks pretend that it was placed in the zodiac to perpetuate the memory of Mochus, the reputed inventor of weights and measures.

The sun enters Libra about the 23d of September, when the autumnal equinox occurs. The sun, being then vertical to the equator, has no declination, and the days and nights are equal all over the earth, except at the poles, where the day closes at the north and opens at the south.

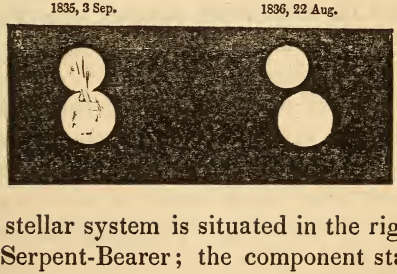
SERPENTARIUS VEL OPHIUCHUS — *The Serpent-Bearer.*

The principal stars are:

| | |
|---|---|
| $\alpha$ *Ras Alhague.* | $\delta$ *First Jed.* |
| $\beta$ *Celbalrai.* | $\varepsilon$ *Second Jed.* |

$\alpha$, in the head, may readily be found by its nearness to Ras Algethi in Hercules. South of $\alpha$ and on each side of it, are the stars $\beta$ and $\varkappa$ in the shoulders; and near these are two smaller stars, $\gamma$ and $\iota$, which form with $\alpha$ an isosceles triangle. About 20° below the stars in the shoulders, are $\eta$ and $\zeta$ in the knees, which form nearly a rectangle with $\beta$ and $\varkappa$. The feet are marked by several small stars in each, below those in the knees.

The appearance of $\tau$ *of the Serpent-Bearer* in the Dorpat telescope is given in the cut.



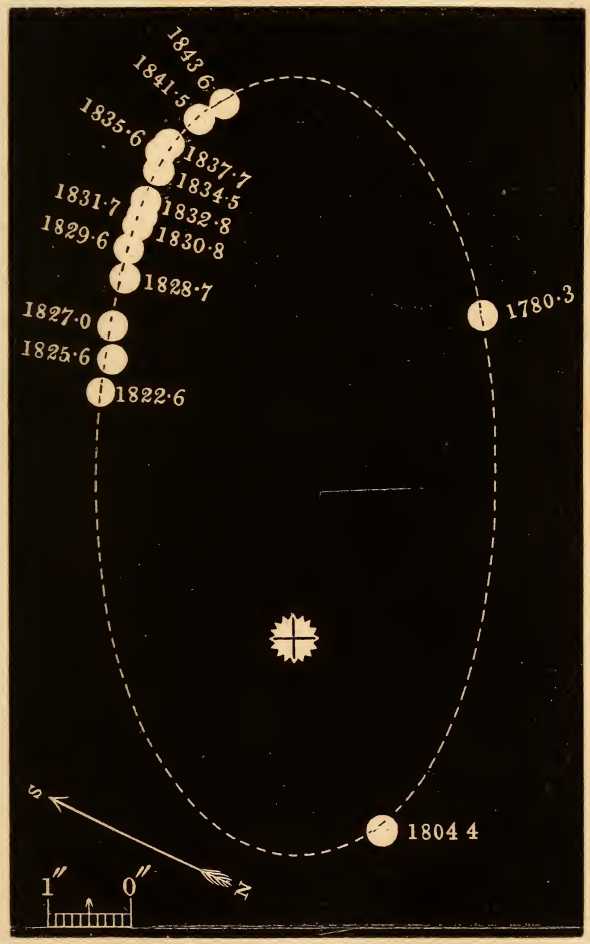

This stellar system is situated in the right arm of the Serpent-Bearer; the component stars are of the 5th and 6th magnitudes, respectively; both yellow. In 1780 this system appeared double, though the components were very close. In 1828 it appeared single. In 1835 the stars were seen

in contact; the distance was $\frac{2}{5}''$. In 1836 the distance was $\frac{3}{5}''$, and the bearing had changed about 10°. In 1841 the distance was $\frac{4}{5}''$. It is still a difficult object for the best telescopes.

THE STELLAR SYSTEM *p of the Serpent-Bearer*. R. A. 269° 9′, Dec. N. 2° 33′.

The orbit of this remarkable system is shown in the figure. It has revolved nearly round since its first discovery by the elder Herschel in 1780. Its period is 93 years, being a little greater than that of the planet Uranus. The component stars are of the 7th and 8th magnitudes. The greater is yellow, the smaller purple. Their mean distance is $4\frac{1}{5}''$. Their present distance is $6\frac{1}{2}''$. They are now nearly at their greatest distance apart. They passed their *perihelion* in 1812. They have both the same proper motion of 112″ in a century among the other stars. The orbit has nearly the same mean distance as $\gamma$ Virginis; but it is less eccentric, as will be noticed by comparing the drawings.

The ellipse of *p of the Serpent-Bearer* is seen in the drawing in perspective, the true orbit being much inclined to the plane of the apparent orbit, and approaching much nearer to the shape of a circle than the drawing. This remarkable stellar system *p of the Serpent-Bearer* has been recommended by Bessel to the special care and attention of astronomers, on account of the shape of its orbit. By measuring the bearing and distance of the components, as well as those of each from




Stellar System *p* of the Serpent Bearer.

other stars in their vicinity, not physically connected with them, astronomers will be enabled in time to determine the motion of each component with respect to their common centre, and consequently their relative masses. If the distance should also be found like that of 61 Cygni, we should then know how the mass of each compares with that of our sun. This system will also be useful in deciding the question, whether the Newtonian law of gravity prevails in the mutual attractions of the stars. Mædler, who has recently discussed this latter question, thinks that the known changes of bearing and distance of these two stars cannot be reconciled with the doctrine of universal gravity, unless we suppose that the actual centre of gravity of each of these suns is different from the apparent centre as estimated in the telescope. Since $\gamma$ Virginis on the contrary confirms the doctrine of the *universality* of *gravitation*, and since Mædler's anomaly may be explained, according to M. Houzeau, by the aberration of the stars' proper motions, we have no reason to consider $p$ of the Serpent-Bearer as forming an exception. The drawing has been made from actual measures of the bearing and distance, without any other supposition than that of an elliptic orbit with the greater component star in the focus.

The other principal double star is,

$\lambda$ Its components are of the 4th and 6th magnitudes; distant 1″; the greater yellow, the smaller bluish. From 1800 to 1825, it did not appear double; since 1825, it has been

separating more and more. The two stars revolve round each other in 88 years; their mean distance is 1″.

In R. A. 252° 0′, Dec. 3° 50′, south, there is a round group of 10′ diameter, containing a multitude of stars somewhat scattered.

In R. A. 271° 0′, Dec. 6° 49′, there is a beautiful, bright, round nebula of 8′ diameter.

In R. A. 260°, Dec. 22°, south, there appeared, in October 1604, a new star, of the 1st magnitude. It disappeared in September 1605. Kepler wrote an interesting work on this star.

FABLE.

SERPENTARIUS VEL OPHIUCHUS.—This constellation was originally Æsculapius, son of Apollo, god of Medicine, but killed by Jupiter with a thunderbolt for his skill, particularly in having restored Hippolytus to life. He is represented as grasping a serpent, the symbol of medicine, as well as of prudence and vigilance.

---

## SERPENS—*The Serpent.*

The head of the Serpent contains two stars, $\gamma$ and $\beta$, of the 3d magnitude, with some smaller ones, and lies directly south of the Northern Crown. $\alpha$, $\delta$ and $\varepsilon$ are immediately below the stars just mentioned, and nearly in a line with $\zeta$, in the knee of Ophiuchus; and $\delta$ and $\varepsilon$ near his left hand. The star $\mu$ is due south of $\varepsilon$ about 10°. A line drawn from $\eta$, in the right knee of Ophiuchus, to $\gamma$, in the Eagle, will indicate the direction of the tail of the Serpent, which contains several

small stars. $\alpha$ is called *Unuk*; $\delta$, *Jed*; $\theta$, *Alya*; and $\lambda$, *Marsik*.

The double stars are:

$\beta$ Its components are of the 3d and 9th magnitudes; distant 31″; bluish white.

$\delta$ of the 3d and 4th magnitudes; distant 3″; the former yellowish white, the latter ash-coloured.

$\theta$ both of the 4th magnitude; distant 22″; yellowish white; easily seen in small telescopes.

In R. A. 218° 4′, Dec. 15° 3′, is a variable star, which, from being of the 8th magnitude, becomes invisible in the period of 353 days, and again increases to the 8th.

In R. A. 235° 22′, Dec. 15° 45′, lies a variable star, which, from the 5th magnitude, becomes invisible in the period of 340 days, and again increases to the 5th.

---

## Delphinus—*The Dolphin.*

This beautiful little constellation, which lies between the Eagle, Antinous and Equüleus, may be easily recognised by four stars, $\alpha$, $\beta$, $\gamma$ and $\delta$, all of the 3d magnitude, which form a rhombus. Of these stars $\alpha$ is called *Svalozin*, and $\beta$ *Rotanew*. A little to the south and west of the rhombus is another star, $\varepsilon$, of the 3d magnitude. This is in the tail, the other four being in the head of the Dolphin.

In this constellation we may notice among the double stars,

$\beta$ whose components are of the 3d and 11th magnitudes, both green, distant 33″.

$\gamma$ of the 4th and 5th magnitudes, distant 12″. The greater is of a deep golden yellow colour, the smaller bluish green.

FABLE.

THE DOLPHIN is said to have been placed among the constellations for the assistance it afforded Neptune in procuring Amphitrite for his wife.

Painters and sculptors represent the dolphin as a crooked hump-backed fish; but, in reality, it is quite straight.

---

## EQUÜLEUS—*The Little Horse.*

This little constellation lies between Pegasus, the Dolphin, and the Water-bearer. It may be known by four stars of the 4th and 5th magnitudes, which form an elongated, irregular trapezium. $\alpha$ is called *Kitalphar.*

$\beta$ is a fine double star, whose components are of the 4th and 12th magnitudes. Sir John Herschel recommends this star as a good object for testing the quality of the best telescopes.

$\varepsilon$ is a triple star, of the 6th, 6th, and 7th magnitudes, whose distances are $\frac{1}{2}''$ and $11''$.

FABLE.

EQUÜLEUS.—This asterism is said to represent the horse which Mercury presented to Castor, and which he named *Celeris.*

---

## SCUTUM SOBIESKI—*Sobieski's Shield.*

SOBIESKI'S SHIELD is one of the constellations instituted by Hevelius, between Antinous and the Serpent's tail, in the Milky-way. It may be

found by a small triangle, formed by three small stars, which is intersected by a line drawn from $\varkappa$, in the knee of Antinous to $\zeta$, in the left knee of Ophiuchus. At a little distance from this triangle, towards the Eagle, are several small stars.

The star 1 varies from the 5th to the 6th magnitude, in a period of 60 days.

In R. A. 280° 45′, Dec. 6° 20′, south, is a large, round, beautiful group of stars, which, with ordinary telescopes, appears as a bright nebula. Diameter 12′.

---

### Turdus Solitarius—*The Solitary Thrush.*

This is north of Libra; was established by Le Monnier. This constellation contains only smaller stars.

---

### Vulpecula et Anser—*The Fox and Goose.*

This constellation is situated south of the Swan, and north of the Dolphin and the Eagle; was established by Hevelius. It contains many small stars, among which may be noticed:

$\zeta$ In R. A. 295° 15′, Dec. 18° 43′, a double star; its components are of the 6th and 9th magnitudes; distant 8″; the greater greenish white, and the smaller blue.

$\theta$ A triple star, 6th, 8th and 7th magnitudes; distances 11″ and 71″; colours respectively, yellowish white, ash-colour and yellow.

In R. A. 294° 40′, Dec. 26° 40′, on the ear of the Fox, Anthelm saw, in June, 1670, a star of the 3d magnitude,

which had diminished to the 5th, in August, and in October of the same year, had entirely disappeared. In March, 1671, he saw i again, of the 4th magnitude; and in March of the following year (1672), it appeared of the 6th magnitude. Since that time it has not been seen.

In R. A. 300° 15′, Dec. 20° 37′, a large group of many stars, of the 10th to the 13th magnitudes, the largest of which is a double star.

In R. A. 290° 45′, Dec. 19° 55′ a group of stars in the form of a trapezium, 3′ long and 2′ wide, and very close.

In R. A. 303° 45′, Dec. 19° 34′, a planetary nebula, beautiful, round and bright, and throughout of the same degree of brightness. It is 2″ in diameter, and around it stand four small stars, like so many satellites.

In R. A. 312° 30′, Dec. 29° 34′, a nebula of 30′ in length and 2′ in breadth, some parts of which are densely studded with very small stars.

In R. A. 298° 0′, Dec. 22° 17′, a very remarkable nebula.

---

## Sagitta—*The Arrow.*

This is a small constellation under the Fox.

### FABLE.

Sagitta.—According to the Greeks this was one of the arrows with which Hercules slew the vulture that gnawed the liver of Prometheus, when chained, by Jupiter's order, on the top of Mount Caucasus.

PLATE X.

CONSTELLATIONS.

| | |
|---|---|
| Sagittarius . . . . . | *The Archer.* |
| Scorpio . . . . . | *The Scorpion.* |
| Lupus . . . . . | *The Wolf.* |
| Ara . . . . . | *The Altar.* |
| Norma, vel Quadra Euclidis | *The Rule.* |
| Telescopium . . . . . | *The Telescope.* |
| Corona Australis . . . | *The Southern Crown.* |

---

SAGITTARIUS—*The Archer,*

Contains the following stars:

| | |
|---|---|
| $\alpha$ *Alrami.* | $\delta$ *The Middle Kaus.* |
| $\beta^1$ *The First Urkab.* | $\varepsilon$ *The Southern Kaus.* |
| $\beta^2$ *The Second Urkab.* | $\lambda$ *The Northern Kaus.* |
| $\gamma$ *Hushuba.* | |

This constellation occupies a large space south of Antinous and Sobieski's Shield. The bow lies in the Milky-way, and is marked by four stars, $\mu$, $\lambda$, $\delta$ and $\varepsilon$, all of the 3d magnitude. The arrow is marked by two stars, $\sigma$ and $\delta$, of the third magnitude, and three small stars in the head; it points towards the Scorpion. The remainder of the constellation is composed entirely of small stars.

Within this constellation there appear:

In R. A. 276° 30′, Dec. 24°, south, a beautiful, round group of stars, of which the brightness rapidly increases towards the centre. The stars of the 9th and 10th magnitudes are dispersed throughout, but the edge is not well defined.

In R. A. 293° 30′, Dec. 14° 33′, south, a planetary nebula, with an obscure round disc of 10″ diameter, with uniform light.

In R. A. 268° 0′, Dec. 23° 1′, south, a forked nebula with three branches, a double star in the middle, and near this star a dark opening.

FABLE.

SAGITTARIUS. — Chiron, the son of Saturn by Philyra, was a Centaur, or twofold being—half man and half horse. He was famed for his skill in medicine, music and archery, and instructed in the polite arts, the greatest heroes of his times. Being accidentally wounded with a poisoned arrow by Hercules, and the wound, which was incurable, causing him great anguish, Chiron prayed Jupiter to deprive him of immortality, that he might, by dying, be relieved from his excruciating pains. Jupiter assented to his request, and changed him into the constellation Sagittarius. The character of this sign (♐) is an arrow; and the figure, a Centaur, in the act of discharging an arrow from a bow: both are supposed to denote the hunting season. The sun enters Sagittarius about the 22d of November.

---

SCORPIO—*The Scorpion,*

Contains the following principal stars:

| | |
|---|---|
| α *Antares.* | ξ *Graffias.* |
| β *Akrab.* | λ *Schaula.* |
| δ *Dschubba.* | υ *Lesath.* |

The position of this constellation is easily determined by means of the bright star Antares,

which is due south of Ras Algethi in the foot of Hercules. West of Antares are $\beta$, $\delta$ and $\pi$, which form a curve; and a little to the east of it is $\tau$. The tail is formed of several stars in a curved line concave upward; the three stars, $\varkappa$, $\lambda$ and $\upsilon$, in the extremity of the tail, forming a small triangle.

Among the double stars are,

$\beta$ of the 2d and 7th magnitudes; distant 14″; white and blue.

$\sigma$ near $\alpha$; of the 5th and 9th magnitudes; distant 21″.

FABLE.

Scorpio. — Orion, a celebrated giant, having impiously boasted that there was not on earth an animal which he could not subdue, Diana, whom he had offended, sent a scorpion, which gave him a mortal sting, and was afterwards metamorphosed into this constellation. The character (♏) is somewhat like the letter *m*, with the last stroke prolonged, and armed with a sting, or dart. It is supposed to be emblematic of the fevers and other diseases which prevail in autumn. In the ancient zodiacs this sign is represented by a snake, a crocodile, Typhon, with scorpions' tails, instead of legs, and a sting in either hand; or with serpents' tails for legs, his body bound round with a snake, and a staff in each hand. The sun enters the Scorpion about the 23d of October.

---

Lupus—*The Wolf,*

Lies to the south, under the Scorpion. This constellation is composed entirely of small stars.

Only the stars in the upper part of the Wolf rise above the horizon of Philadelphia.

---

ARA—*The Altar,*

Consists of small stars only. It is situated under the Scorpion's tail, and is not visible in the latitude of Philadelphia.

---

NORMA, VEL QUADRA EUCLIDIS— *The Rule and Square.*

*The Rule and Square* is between the tail of the Scorpion and the Wolf. This constellation was instituted by Lacaille, and only the northern part of it rises above our horizon.

---

TELÉSCOPIUM—*The Telescope,*

Between Sagittarius and the Scorpion, was likewise introduced by Lacaille. It is composed only of small stars, of which the northern ones alone are ever above our horizon.

---

CORONA AUSTRALIS—*The Southern Crown,*

Between Sagittarius and the Telescope, is composed of small stars, the largest being of the 5th magnitude.

---

PLATE XI.

CONSTELLATIONS.

| | |
|---|---|
| Aquarius . . . . . | *The Water-bearer.* |
| Capricornus . . . . | *The Goat.* |
| Piscis Australis . . . | *The Southern Fish.* |
| Globus Ærostaticus . | *The Balloon.* |
| Microscopium . . . | *The Microscope.* |
| Grus . . . . . | *The Crane.* |
| Phœnix . . . . . | *The Arabian Bird.* |
| Apparatus Sculptoris . | *The Sculptor's Tools.* |
| Indus . . . . . | *The Indian.* |

AQUARIUS—*The Water-bearer.*

The principal stars in this constellation are:

| | |
|---|---|
| $\alpha$ *Sadalmelik.* | $\delta$ *Scheat.* |
| $\beta$ *Sadalsude.* | $\theta$ *Ancha.* |
| $\gamma$ *Sadachbia.* | $\varkappa$ *Situla.* |

$\alpha$ and $\beta$ in the shoulders form with $\varepsilon$ in the nose of Pegasus and $\alpha$ of Equuleus, a quadrilateral figure, nearly rectangular. 5° to the east of $\alpha$ is $\gamma$ in the right arm; and east of $\gamma$ are three small stars, two of which, $\eta$ and $\varkappa$, with $\gamma$, form a right-angled triangle. These last are in the Urn, from which there issues a stream of water, which contains a number of small stars. $\delta$ in the right leg forms with $\beta$ and $\gamma$ an isosceles triangle, whose vertex is at $\gamma$.

Of the double stars, we remark:

$\zeta$ in the right hand, both of whose components are of the 4th magnitude; distant 3″; colour greenish white.

In R. A. 339° 45′, Dec. 5° 8′, south, a triple star, of the 7th, 8th and 9th magnitudes; distances 4″ and 56″.

In R. A. 347° 30′, Dec. 14° 24′, south, a double star, of the 5th and 7th magnitudes; distance, 13″; light yellow, and blue.

In R. A. 353° 32′, Dec. 16° 23′, south, a changeable star, which, in a period of 382 days, fades from the 6th magnitude, until it entirely disappears, and again increases to the 6th.

In R. A. 321° 15′, Dec. 1° 34′, south, a large, round, beautiful group of stars, easily resolvable, very bright toward the middle. The brightest part is 6″ in diameter.

In R. A. 313° 45′, Dec. 12° 2′, south, a planetary nebula, with a round disc, equally light throughout, and of 5′ diameter.

### FABLE.

Aquarius is supposed to be the same with Ganymedes, son of Tros, the builder of Troy, whom Jupiter translated to heaven to be his cup-bearer; or, according to other accounts, he is the representative of Deucalion, in whose time the Thessalian deluge happened. The character of this sign (♒) is a natural representative of gentle waves; and the figure, that of a man pouring out water from an urn, indicative of the moisture which prevails while the sun is passing through it. In the Egyptian zodiac, Canopus, with his pitcher, or cubit of justice, appears as the prototype of Aquarius with his urn. In the circular zodiac of Dendera, Aquarius is walking with a cup in each hand, while he balances upon a line or fine chain. At Esné, he appears in the same attitude, but with only one cup in his left hand, from which a

line or chain is hanging down. In the Egyptian zodiac, constructed by the second Hermes, Canopus, or Aquarius, is represented under the symbol of the *Dea Multimamia;* and from the numerous paps on the body, an abundance of milk appears to flow, in allusion to the benefits derived from the overflowing of the Nile. In the Oriental zodiac, he sustains a vase, or cup of libation, in his right hand, and is habited in princely robes. The Etruscans represented the sun in Aquarius by Janus seated on a throne composed of twelve altars. The Egyptians call this sign Mon, or Meon, which is a solar title of very remote antiquity, and indicative of a season of great moisture. The sun enters Aquarius about the 20th of January.

---

### Capricornus—*The Goat.*

The principal stars in this constellation are:

$\alpha^1$ *first Dschabe.*
$\alpha^2$ *second Dschabe.*
$\beta$ *Dschabih.*
$\nu$ *Nashirah.*
$\delta$ *Scheddi.*

This constellation lies south of the Dolphin and Antinous, and west of Aquarius. $\delta$ in the tail forms with $\delta$ and $\gamma$ of Aquarius, an isosceles triangle, of which $\gamma$ is at the vertex. About 20° west of $\delta$ is $\beta$ in the head; and a little above $\beta$ are $\alpha$, $\nu$ and $\xi$ in the horns. Below $\beta$ are the stars $\pi$ and $\rho$ in the head; and still lower in the same direction, are $\psi$ and $\omega$ in the leg.

In R. A. 302° 45′, Dec. 15° 19′, south, a very fine double star, a difficult object to detect; of the 17th and 18th (Herschel's) magnitudes; distance 3″; near β Capricorni. Sir John Herschel selects this as a test object for the best telescopes.

FABLE.

Capricornus.—Pan, or Bacchus, fleeing from the giant Typhæus into the river Nile, transformed himself into a sea-goat, and Jupiter made him a constellation. Or, Amalthæa, daughter of Melissus, king of Crete, nourished the infant Jupiter with goats' milk and honey; for which service she was translated to the heavens, in the constellation Capricornus. The character of this sign (♑) is supposed to have some resemblance to the tail of a goat; but it is more probably an ancient mark for the name. The figure is sometimes that of a monster, partly a goat and partly a fish; but sometimes like a common goat, an animal fond of mounting, and therefore emblematical of the sun, which, having in this sign reached his greatest southern declination, begins to reascend toward the north. In the Egyptian zodiac, the sea-goat is held in a string by Anubis. In the Indian zodiac, this sign is represented by a goat *passant*, traversed by a fish; on the Oriental zodiac of Sir W. Jones, it is a fish swallowing an antelope, and surrounded by aquatic birds; and in Moor's Hindoo Pantheon, Capricornus is represented by an antelope. The sun enters Capricornus about the 21st of December.

PISCIS AUSTRALIS—*The Southern Fish.*

This constellation is situated under Aquarius. It is readily distinguished by means of $\alpha$, or *Fomalhaut*, a star of the 1st magnitude, which, with the two stars $\beta$ and $\varepsilon$, forms a nearly equilateral triangle. These three are the only important stars in this constellation.

GLOBUS ÆROSTATICUS—*The Balloon.*

This constellation is situated under Capricornus, and west of the Southern Fish. It was introduced by Lalande.

MICROSCOPIUM—*The Microscope,*

Is situated between Sagittarius and the Balloon. It was instituted by Lacaille.

GRUS—*The Crane,*

Is south of the Southern Fish. It contains one star of the second magnitude, two of the third, and two of the fourth.

PHŒNIX—*The Phœnix, or Arabian Bird,*

Is situated east of the Crane.

APPARATUS SCULPTORIS—*The Sculptor's Tools,*

Lies between the Phœnix and the Whale.

INDUS—*The Indian,*

Is under the Microscope, and westward from the Crane.

---

The six last named constellations all lie very far south; only their northern parts rise to our view at Philadelphia.

---

PLATE XII.

CONSTELLATIONS.

| | |
|---|---|
| Cetus . . . . . | *The Whale.* |
| Eridanus . . . . | *The River Po.* |
| Lepus . . . . . | *The Hare.* |
| Harpa Georgii . . | *George's Harp.* |
| Sceptrum Brandenburgium . | *Sceptre of Brandenburgh.* |
| Apparatus Chemicus | *Chemical Apparatus.* |
| Machina Electrica . | *Electrical Machine.* |
| Cælum Sculptoris . | *The Graver.* |
| Horologium . . . | *The Clock.* |

---

CETUS—*The Whale.*

The principal stars are:

α *Menkar.*
β *Diphda* or *Deneb Kaitos.*
ο *Mira.*
ζ *Batan Kaitos.*

This is one of the largest constellations in the

heavens. It lies chiefly under Aries and Pisces. The head and neck of this sea-monster may be known by the three stars, $\alpha$, $\delta$ and o, lying in a right line, $\delta$ being midway between the other two. $\alpha$ forms an equilateral triangle with the Pleiades and $\alpha$ of Aries. A little above $\delta$ is $\gamma$, and a line drawn from $\gamma$ through o will show us $\theta$ and $\eta$ a little above the line, and $\zeta$, $\beta$ and $\tau$, a little below it. A line drawn from the Pleiades through $\alpha$, will point out four stars, $\varepsilon$, $\pi$, $\varrho$ and $\sigma$, of the 4th magnitude, forming a parallelogram.

Among the double stars are:

$\gamma$ Its components are of the 3d and 7th magnitudes; distant 2″.6; yellow and ash-coloured. Their proper motion among the other stars is 21″ in a century.

$\nu$ 5th and 10th magnitudes; distant 8″; yellow and ash-coloured.

$\chi$ 5th and 7th magnitudes; distant 4″; white, and yellowish white.

$\tau$ is remarkable for its extraordinary proper motion of 181″ in R. A. and 92″ in Dec. in a century.

o called *Mira*, or the wonderful, on the neck of the Whale; a remarkable double star, of which the smaller can only be seen with the best telescopes, at a distance of 113″ from the greater. The greater is variable, changing from the 2d magnitude to invisibility, and again to the 6th, in the period of 332 days.

In R. A. 359° 0′, Dec. 21° 40′, south, is situated a group of stars in the form of a triangle.

### FABLE.

CETUS.—The name of this extensive constellation, which occupies a greater space than any in the firmament, is derived, according to poetical

fiction, from the sea-monster which went to devour Andromeda. It was struck dead on beholding the head of Medusa, which Perseus presented to it, and was afterwards placed among the stars.

---

## Eridanus—*The River Po.*

Eridanus, under Cetus and Taurus, and west of Orion.

| | |
|---|---|
| α *Achernar.* | ζ *Zibal.* |
| β *Cursa.* | η *Azha.* |
| γ *Zaurak.* | ο *Beid.* |
| δ *Rana.* | υ *Themin.* |

This constellation may be traced from Rigel in the foot of Orion, under the Harp to the Whale; and thence, S. E. and S. W. in a serpentine direction till it sinks below the horizon. The principal stars visible in our latitude are, γ, midway between Rigel and the parallelogram in the Whale; η, near this parallelogram, in a line with γ and ο of the Whale; δ, about 5° N. W. of γ; s, making an equilateral triangle with η and δ; and υ, in a line with ο in the neck of the Whale, and s of the River.

The double stars are as follows:

In R. A. 56° 15′, Dec. 3° 27′, south. Its components are of the 4th and 6th magnitudes; distant 7″. The greater is yellow, and the smaller blue.

In R. A. 61° 56′, Dec. 7° 54′, south; a double star of the 5th and 8th magnitudes; distant 80″. This double star has, next to 61 Cygni and μ Cassiopœia, the greatest proper

motion. It amounts in a century to 219″ in R. A. and to 345″ in Dec., whilst the distance of the two stars from each other hardly changes.

FABLE.

ERIDANUS, an ancient and celebrated river of Italy (now the Po), was made a constellation, because it received Phaëton when stricken of thunder by Jupiter, after he had set the world on fire by his inexperience and temerity in presuming to drive the chariot of the Sun, his father.

## LEPUS—*The Hare.*

This is a small constellation, lying immediately under Orion. It may be known by the four principal stars, $\alpha$ or *Arneb*, $\beta$ or *Nihal*, $\gamma$ and $\delta$, forming a trapezium. About 4° south of Rigel are four small stars in the ears of the Hare. $\varepsilon$ forms with $\alpha$ and Rigel a triangle, right-angled at $\alpha$.

$\iota$ On the left ear, in R. A. 76° 0′, Dec. 12° 5′, south, is a double star. Its components are of the 4th and 10th magnitudes; distant 13″; the greater greenish, and the smaller yellow.

$\varkappa$ on the same ear, in R. A. 76° 15′, Dec. 13° 9′, south, is a double star of the 5th and 8th magnitudes; distant 3″; the greater is yellow, and the smaller blue.

## HARPA GEORGII—*George's Harp.*

*The Harp*, between Taurus and Eridanus, eastwardly from the head of the Whale, was estab-

lished by Hell in the year 1791, in honour of George III. of England.

---

Sceptrum Brandenburgium — *The Sceptre of Brandenburgh.*

*The Sceptre,* or the *Brandenburgh Sceptre,* is situated between the Hare and the Harp. It consists of three small stars in a vertical line between Rigel and the parallelogram in the Whale, about one-fourth the distance from Rigel. It was formed in 1688 by Kirch, a Prussian astronomer.

---

Apparatus Chemicus—*The Chemical Apparatus,*

Is in the southern curve of Eridanus, and was instituted by Lacaille.

---

Machina Electrica—*The Electrical Machine,*

Under the Whale, and west of the Chemical Apparatus, was instituted by Bode.

---

Caela Sculptoris—*The Graver,*

Is south of the Sceptre, and west of the Hare. It was formed by Lacaille.

---

HOROLOGIUM—*The Clock,*

Between the Graver and Phœnix, was formed by Lacaille.

The last six constellations are composed, for the most part, of very small stars.

---

PLATE XIII.

CONSTELLATIONS.

| | |
|---|---|
| Canis Major . . . . | *The Great Dog.* |
| Argo Navis . . . . | *The Ship Argo.* |
| Columba . . . . . | *The Dove.* |
| Felis . . . . . | *The Cat.* |
| Equüleus Pictoris . . | *The Painter's Easel.* |
| Officina Typographica | *The Printing Press.* |
| Pyxis Nautica . . . | *The Mariner's Compass.* |

---

CANIS MAJOR—*The Great Dog.*

The principal stars are:

| | |
|---|---|
| α *Sirius.* | ε *Udara.* |
| β *Mirza.* | ζ *Furud.* |
| γ *Muliphein.* | η *Aludra.* |
| δ *Wezen.* | |

This constellation lies to the S. E. of Orion. Sirius is the brightest of all the fixed stars. It is

in the head of the Dog, nearly in a line with the three stars in the belt of Orion. $\gamma$ in the head, and $\beta$ in the left fore-paw, are nearly in a line with Sirius. About 15° S. E. of Sirius are three stars of the 2d magnitude, $\delta$, $\varepsilon$ and $\eta$, forming a triangle right-angled at $\delta$; and between $\delta$ and $\varepsilon$, is $\sigma$ of the 3d magnitude. $\zeta$, in the left hinder-paw, forms with $\beta$, $\alpha$ and $\varepsilon$, a trapezium, which is very nearly a rectangle. Besides the above, there are several stars of the 4th magnitude, and many smaller ones which may be easily found.

Among the double stars are:

$\mu$ in R. A. 102° 0′, Dec. 13° 50′, south. Its components are of the 5th and 8th magnitudes; 3″ apart; yellow and blue.

$\nu$ in R. A. 97° 15′, Dec. 18° 31′, south, of the 6th and 8th magnitudes; 17″ apart; the greater reddish, the smaller blue.

### FABLE.

Canis Major, according to the Greeks, was one of Orion's hounds; but the Egyptians, who judged of the rising of the Nile by the rising of this constellation, or rather of the great star Sirius, which is comprised in it, represented it by the figure of a dog, the symbol of a watchful and faithful monitor. It was the representative of their deity Anubis, and had the same relation to the Nile that Cerberus had to the sun.

## Argo Navis—*The Ship Argo.*

The principal stars in this constellation are:

α *Canopus.*
ζ *Naos.*
κ *Markeb.*

Of this extensive constellation, only the northern part rises above our horizon. The star Canopus, of the first magnitude, on the end of the rudder, is in brilliancy nearly equal to Sirius, but it does not rise to our view.

The prow of the ship may be known by three stars of the 3d magnitude, ι, κ and π, S. E. of the stars in the lower part of the Great Dog, which with several smaller stars form a curve convex towards the Dog. A line drawn from γ in the head, through η in the tail of the Great Dog, and produced as far below η as γ is above it, will terminate in ζ, a star of the 2d magnitude. 7° due south of ζ is γ, also of the 2d magnitude. A line drawn from Sirius through η in the tail of the Dog, will point out λ, of the 2d magnitude. Due south of Sirius, and on a parallel line with λ, is ν. The other principal stars are too far south to be seen in our latitude.

The double stars are:

In R. A. 114° 22′, Dec. 14° 16′, south. Its components are of the 6th and 7th magnitudes; distant 16″; both white.

In R. A. 115° 0′, Dec. 11° 46, south, of the 5th and 7th magnitudes; distant 3″; the greater yellow, and the smaller blue.

FABLE.

ARGO NAVIS.—This constellation is believed by many to derive its name from the celebrated ship Argo, in which Jason and his companions went to Colchis, in quest of the golden fleece, and afterwards visited nearly all the known world. When the expedition was finished, Jason consecrated his ship to the god of the sea, and it afterwards became a constellation. Others suppose it was the ship in which Danaüs migrated from Egypt to Greece; and all agree that it was the first long vessel ever built. In truth, the ship Argo is no other than the Ark of Noah.

---

COLUMBA—*The Dove.*

This lies southerly, under the Great Dog. It was introduced by Roger, in the year 1679.

---

FELIS—*The Cat,*

Between Hydra and the Compass, was placed in the heavens by Lalande.

---

EQUULEUS PICTORIS—*The Painter's Easel,*

Between the Ship, the Dove, and the Graver, was introduced by Lacaille.

---

OFFICINA TYPOGRAPHICA—*The Printing Press,*

Between the head of the Great Dog, the Unicorn, and the Cat, was introduced by Bode.

---

PYXIS NAUTICA—*The Compass,*

Between the Cat and the northern part of Argo Navis, was established by Lacaille.

The band slung around it denotes the *line,* or *log-line,* added by Bode.

---

PLATE XIV.

CONSTELLATIONS.

| | |
|---|---|
| Hydra . . . . . | *The Water-Serpent.* |
| Crater . . . . . | *The Cup.* |
| Centaurus . . . . . | *The Centaur.* |
| Corvus . . . . . | *The Crow.* |
| Antlia Pneumatica . . | *The Air Pump.* |
| Robur Caroli . . . . | *Charles' Oak.* |
| Crux . . . . . | *The Cross.* |

---

HYDRA—*The Water-Serpent.*

*The Water-Serpent* is a very large constellation, extending under the Crab, the Lion, and the Virgin. The head may be known by four small stars situated south of the Crab, $\delta$, $\varepsilon$, $\zeta$ and $\eta$; the first of these is of the 3d, and the others are of the 4th magnitude. The star $\alpha$, called *Alphard,* or *Cor*

*Hydræ*, is about 20° S. E. of the head; there is no other bright star near it for which it can be mistaken: a line drawn from $\gamma$ of the Lion, through Regulus, will show us this star, about 20° S. W. of Regulus. The three small stars, $\tau$, $\iota$ and $\theta$, north of Alphard, mark the first coil. From $\alpha$, it winds by a serpentine course under the Sextant, the Cup and the Raven, and is marked by a number of small stars, which may easily be found by the aid of the map, when the positions of these other constellations are known. South of Spica, may be found the two stars $\gamma$ and $\pi$, in the tail, which form, with Spica, a triangle, right-angled at $\gamma$.

Among the double stars are:

$\varepsilon$ of the 4th and 8th magnitudes; distance 3″; yellow and blue.

In R. A. 126° 30′, Dec. 7° 14′; of the 6th and 7th magnitudes; distant 10″; yellowish and reddish yellow.

u Hydræ in R. A. 199° 42′, Dec. 22° 15′, south, is a variable star, which changes from the 5th magnitude to invisibility in a period of 494 days.

### FABLE.

Hydra.—This constellation is said to represent the Lernæan hydra, the destruction of which constituted one of the twelve labours of Hercules. Or, more probably, it was emblematic of the Nile at the period of inundation, if not of the poetic deluge.

## Crater—*The Cup.*

*The Cup* lies under the Great Lion, and between this constellation and the middle of Hydra. A line drawn from Arcturus, through $\delta$ of the Virgin, will pass through it. The three principal stars, $\alpha$, or *Alkes*, $\beta$ and $\delta$, form an isosceles triangle, whose vertex is at $\alpha$. $\gamma$ and $\zeta$ are in a line with $\alpha$, and $\gamma$ and $\theta$ are in a line with $\beta$.

In R. A. 178° 15′, Dec. 17° 55′, are two nebulæ running into each other. Both are much brighter toward the middle than near the edge.

### FABLE.

Crater.—This cup, or goblet, was attributed to Bacchus by the mythologists, and seems an allegorised symbol of Noah's discovery of the art of making wine. The fabulists farther pretend that Apollo, intending to sacrifice to Jupiter, sent a crow with a cup to fetch water; but the bird, being of a vagrant disposition, wasted his time in idle amusements, and at last, returning without the water, told Apollo that the stream was guarded by a venomous serpent. This falsehood was easily detected; and Apollo, to punish the bird, placed him opposite to the cup, and charged the serpent never to allow him to drink.

---

## Centaurus—*The Centaur.*

*The Centaur* lies between the tail of Hydra and the northern part of Argo Navis, and south of the

Virgin. Only the northern part of this constellation rises to our view. Directly south of Spica, several small stars in the head, and $\iota$ and $\theta$ in the shoulders, may be seen.

FABLE.

Centaurus. — The Centauri were a people of Thessaly, who, as the mythologists pretended, were the progeny of Ixion and Nephele, or a cloud; and they were represented as monsters, half men and half horses. A celebrated warfare was maintained between them and their neighbours, the Lapithæ, which ended in the overthrow of the Centauri.

---

Corvus—*The Crow, or Raven.*

*The Crow*, east of the Goblet, and south of the Virgin, may be easily recognised by four stars, of the third and fourth magnitudes, which form a quadrangle. A line drawn through $\varepsilon$ and $\delta$ of the Virgin, would pass through $\delta$ and near $\varepsilon$ and $\alpha$ of the Crow. $\delta$ and $\beta$ of the Crow are in a line with $\eta$ Virginis, and $\beta$ and $\gamma$ are nearly in a line with $\beta$ of the Virgin.

FABLE.

Corvus.—This constellation is said to have been the Crow into which Apollo metamorphosed himself when fleeing from the giant Typhæus; and

which was afterwards punished for insincerity, as is stated in the fable of the *Crater*.

---

ANTLIA PNEUMATICA—*The Air-Pump.*

*The Air-Pump* is between Hydra, the Goblet, and Argo Navis, and was introduced by Lacaille.

---

ROBUR CAROLI—*Charles's Oak.*

*Charles's Oak,* between the Centaur and the northern part of Argo Navis, was placed in the heavens by Halley, in memory of King Charles II., of England.

In R. A. 159° 0′, Dec. 58° 40′, south, near the star $\eta$ of the oak, stands a very remarkable nebula, which has the appearance of a *leg of mutton.*

---

CRUX—*The Cross,*

With one star of the 1st, two of the 2d, and one of the 3d magnitude, was instituted by Roger in the year 1679.

Charles's Oak and the Cross do not rise above our horizon. These and the constellations further south are never visible to us; it will therefore be sufficient to give their names and places here. They will all be found on the map of the Southern Hemisphere.

| | Right Ascension. | | | | South Declination. | | | |
|---|---|---|---|---|---|---|---|---|
| TUCAN—*The American Goose* | From | 330° | to | 20° | From | 58° | to | 73° |
| OCTANS HADLEIANUS—*Hadley's Octant* | " | 170 | " | 360 | " | 75 | " | 90 |
| HYDRUS—*The Male Water Serpent* | " | 10 | " | 60 | " | 62 | " | 82 |
| RETICULA RHOMBOIDALIS—*The Rhomboidal Net* | " | 54 | " | 70 | " | 59 | " | 67 |
| DORADO VEL XIPHIAS—*The Sword Fish* | " | 60 | " | 110 | " | 50 | " | 76 |
| MONS MENSIFORMIS—*Table Mountain* | " | 55 | " | 140 | " | 75 | " | 85 |
| PISCIS VOLANS—*The Flying Fish* | " | 105 | " | 135 | " | 66 | " | 68 |
| CHAMELEON—*The Cameleon* | " | 110 | " | 180 | " | 68 | " | 81 |
| APIS—*The Bee* | " | 182 | " | 210 | " | 63 | " | 76 |
| APIS VEL AVIS INDICA—*The Bird of Paradise* | " | 180 | " | 260 | " | 67 | " | 83 |
| CIRCINUS—*The Compasses* | " | 215 | " | 234 | " | 54 | " | 65 |
| TRIANGULUM AUSTRALE—*The Southern Triangle* or *Level* | " | 220 | " | 252 | " | 62 | " | 69 |
| PAVO—*The Peacock* | " | 265 | " | 316 | " | 57 | " | 75 |
| INDUS—*The Indian* | " | 300 | " | 343 | " | 48 | " | 74 |

Among the objects near the South Pole, the following are remarkable:

The two *Black Clouds*, called also *Cap-Clouds*, *Magellan's Spots*, and *Coal-Bags*. The great black cloud extends from R. A. 185° 15′ to 196° 15′, and in Dec. from 61° to 64° south, and it lies on the east side of the Southern Cross. The double small black cloud is in R. A. 160° 0′, and Dec. 62° south, near Charles's Oak. Both these striking dark spots are in a very bright part of the Milky-way.

The two *Southern Clouds* are bright extensive nebulæ. The great Southern cloud extends from R. A. 76° 45′ to 90° 0′, and from Dec. 69° to 71° south, and lies nearly on the South Pole of the Ecliptic. The small Southern Cloud lies in R. A. 27° 30′, and Dec. 73° 10, south.

## SEC. 12.

### THE CALENDAR OF THE STARS, OR AN EASY METHOD OF FINDING THE STARS FOR EVERY SEASON OF THE YEAR.

### JANUARY.

*About the Middle of the Month, at Half-past Nine o'clock in the Evening.*

The constellation Orion (Plate VI.) is nearly on the meridian; and below him are the Hare and Dove (Plates XII. and XIII). The principal stars of Orion form a large quadrilateral, of which the two principal are in the shoulders: the Eastern, or principal star, is called *Betelguex*, and the western one *Bellatrix*. To the southward of them are three conspicuous stars, at equal distances from each other, called the *belt* of Orion. To the southward of his belt is his *sword;* formed by a row of stars less brilliant than the belt. At about the same distance to the southward of the belt as Betelguex is to the northward of it, is *Rigel;* and at the same distance from Rigel that Betelguex is from Bellatrix, is a star called *Saiph*, on the knee, which, with the three last mentioned, forms the quadrangle enclosing the belt and sword.

At an equal distance from Betelguex and Bellatrix, are three small stars, which constitute the head of Orion.

The Little Dog (Plate VI.) is about 45 degrees high in the S. E.

*Capella*, the principal star in the CHARIOTEER (Plate VI.), is near the zenith.

*Sirius*, in the GREAT DOG (Plate XIII.), is in the S. S. E. It forms nearly an equilateral triangle with Procyon and Betelguex, being the southern point.

*Alphard*, or *Cor Hydræ*, in the WATER SERPENT (Plate XIV.), is in the E. S. E. about 19 degrees high.

*Castor* and *Pollux*, in the TWINS (Plate VI.), are in the east. The altitude of the former is 63 degrees, and of the latter 58. The foot of Pollux is about 60 degrees high, S. E.

*Regulus*, or *Cor Leonis*, in the LION (Plate VIII.), is nearly due E. about 22 degrees high. *Denebola*, in the tail, is nearly E. N. E. about 5 degrees high.

A line drawn from Regulus to Procyon, will pass the stars in the head of the WATER SERPENT (Plate XIV.), which are nearly at equal distances from these two.

BERENICE'S HAIR (Plate VIII.) is about 5 degrees high, N. E. by E.

COR CAROLI (Plate III.) is in the N. E. about 10 degrees high. It is situated in the neck of Chara.

*Chara* and *Asterion* are in the constellation of the HOUNDS (Plate III).

Cor Caroli forms a triangle with Benetnasch in the tail of the GREAT BEAR, and the third on the tip of the tail.

In N. E. by N. are seen the seven stars in URSA MAJOR (Plate IV). *Dubhe* is 37 degrees

high; *Alioth*, in the tail, 22; and *Benetnasch*, 12 degrees high.

The principal star in the DRAGON (Plate III.) is about 20 degrees high, N. N. E.

Between the Great Bear and the Lion, is the LITTLE LION (Plate IV).

A line drawn from Regulus through the Little Lion to the first and second stars, called *the Pointers*, in the Great Bear, will pass through the eleventh and twelfth of that constellation, in his left hind-foot.

A little W. of the meridian is the BULL (Plate VI). *Aldebaran*, the principal star, surrounded by the HYADES, is about 65 degrees high, and his horns are on the meridian. The PLEIADES are about 66 degrees above the horizon, S. W. by S.

Nearly in the S. S. W. the star $\gamma$ in the RIVER Po (Plate XII.), is about 33 degrees high.

*Menkar*, in the WHALE (Plate XII.), is about 43 degrees high, S. W. by S.

The RAM (Plate V.) is seen S. W. by W. and W. S. W. $\alpha$ *Arietis*, called the *Eastern Horn*, is about 47 degrees high.

*Algol*, in MEDUSA'S HEAD (Plate IV.), is above the Ram, about 66 degrees high.

If a line be drawn obliquely from this last star to the zenith, it will pass near three other stars at almost equal distances from each other: the highest is *Alamach*, in the foot of ANDROMEDA (Plate V.); the next is *Mirach*, in the girdle; and the

lowest represents *Alpheratz*, her head, and the principal star in the constellation.

Below Andromeda's head, the constellation PEGASUS (Plate V.) is remarkable by its three stars, which form a square with Alpheratz. *Markab* is about 8 degrees high; *Algenib* due W. 20 degrees high; and *Scheat* W. N. W. 15 degrees high.

A line drawn from *Pollux*, in the TWINS (Plate VI.), to *Regulus*, in the LION (Plate VIII.), passes through the CRAB (Plate VI.).

In the N. W. by W. the *W* formed by the five principal stars in CASSIOPEIA (Plate IV.), is about 45 degrees high.

N. W. by N. *Deneb*, called also *Arided*, in the tail of the SWAN (Plate III.), is about 7 degrees high.

The two bright stars in the DRAGON (Plate III.) are due N. just at the horizon.

CEPHEUS (Plate III.) is seen between the Dragon and Cassiopeia.

The *guards* in the LITTLE BEAR (Plate III.), are at a little distance from the meridian.

---

## FEBRUARY.

*The Middle of the Month, about Half-past Nine o'clock.*

*Procyon*, in the LITTLE DOG (Plate VI.), is a little east of the meridian, about 55 degrees high; and a little higher is the second star in the constellation.

*Castor* and *Pollux*, in the TWINS (Plate VI.), are about 25 degrees above Procyon.

N. of Gemini is the LYNX (Plate IV.); and S. of the Little Dog is the UNICORN (Plate VI.).

*Alphard* or *Cor Hydræ* (Plate XIV.), is nearly S. E., 34 degrees high.

*Cor Leonis*, or *Regulus*, in the LION (Plate VIII.), is about 44 degrees high, in the E. S. E.: the star $\gamma$ in the Lion is about 8 degrees N. E. of it; *Denebola*, in the tail, is in the E., about 28 degrees high; and $\delta$ in this constellation is 10 degrees above Denebola.

*Alphard*, the *Hydra's Heart*, forms, with Cor Leonis and Procyon, a large triangle.

The two small stars E. by N. are in the hind-foot of the GREAT BEAR (Plate IV.), about 42 degrees high: two others are in the upper hind-foot, about 14 degrees above the two former.

Nearly N. E. are the *seven stars* in the Great Bear, known by the name of *Charles's Wain:* the lowest, called *Benetnasch*, is at the tip of the tail, about 25 degrees high; *Dubhe*, the northernmost, and one of the pointers, is 50 degrees high.

COR CAROLI (Plate III.) is 27 degrees above the horizon, N. E. by E.

BERENICE'S HAIR (Plate VIII.) is very conspicuous, between Denebola and Cor Caroli.

*Etanin*, the second star of the DRAGON (Plate III.), and the third, are N. by E. about 5 degrees

high; the first, or $\alpha$, is about 30 degrees high, in the N. E. by N.

The VIRGIN (Plate VIII.), is partly risen in the E.

*Betelguex*, in the right shoulder of ORION (Plate VI.), about 54 degrees high; and *Rigel*, in his left foot, about 34 degrees high, are nearly in the S. W. *Bellatrix*, the star in the left shoulder, is about 49 degrees high. The three stars in the middle are called his *belt*.

*Sirius*, in the GREAT DOG (Plate XIII.), about 33 degrees high, a little W. of the meridian, forms, with Bellatrix and Procyon, a large triangle.

The south horn of the BULL (Plate VI.) is about 62 degrees high, S. W. by S.; and the northern horn is 66 degrees high, W. S. W. *Aldebaran*, the eye, is 50 degrees high. The *Pleïades* are more to the W., 45 degrees high.

*Capella*, or *Alioth*, in the CHARIOTEER (Plate VI.), is W. N. W., about 68 degrees high; and the second star, of the second magnitude, in the right shoulder, is 76 degrees high.

*Menkar*, in the WHALE (Plate XII.), is about 25 degrees high, W. by S.

$\alpha$, in the northern horn of the RAM (Plate V.), is about 25 degrees high, W. by N.

MEDUSA'S HEAD (Plate IV.), is about 45 degrees high, nearly W. N. W.

*Alamach*, in ANDROMEDA (Plate V.), is about 34 degrees high, N. W. by W.; and below it is *Mirach*, 22 degrees high.

The principal stars in PERSEUS (Plate IV.) are above Alamak.

CASSIOPEIA (Plate IV.) is nearly N. W. by N.

CEPHEUS (Plate III.) is N. by W.

The body of the LITTLE BEAR (Plate III.) is between the Dragon and the Pole-star.

---

## MARCH.

*Middle of the Month, about half-past Nine o'clock.*

*Alphard*, or *Cor Hydræ*, in the WATER-SERPENT (Plate XIV.), is near the meridian, about 42 degrees high.

*Cor Leonis*, or *Regulus*, in the LION (Plate IV.), is a little to the E. of the meridian, about 60 degrees high; and above it are five others in the head and mane. One on the back is about 58 degrees high, E. S. E.; and *Denebola*, in his tail, is a little more eastward, 48 degrees high.

*Spica*, in the VIRGIN (Plate VIII.), is nearly S. E. by E, about 14 degrees high. Between Spica and Denebola, in the Lion, are five or six stars in the Virgin. *Vindemiatrix*, in this constellation, is more to the E., and about 33 degrees high.

*Arcturus*, in BOÖTES (Plate VII.), is E. by N., about 24 degrees high.

Spica, Denebola, and Arcturus, form a triangle almost equilateral.

Regulus, or Cor Leonis, Cor Caroli, and Vinde-

miatrix, in the Virgin, form a triangle, within which is BERENICE'S HAIR (Plate VIII).

*Mirach*, in Boötes, is about 23 degrees high, E. by N. E.; and the two stars in his shoulder are a little more E.

The NORTHERN CROWN (Plate VII.) is below these two stars; and *Alphecca*, the principal star in this constellation, is about 13 degrees high.

*Alkalurops*, in the head of Boötes, is nearly N. E. by E., about 27 degrees high.

*Benetnasch*, the lowest star in the tail of the GREAT BEAR (Plate IV.), is about 42 degrees high, N. E. by E.; *Mizar* about 6 degrees higher, and *Alioth* about 4 degrees higher still.

The LITTLE BEAR (Plate III.) is in a favourable position for observation; and between this constellation and the three stars above-mentioned, in the Great Bear, the principal star in the DRAGON (Plate III.) may be seen in the N. E., 42 degrees high. More to the N. and about 30 degrees lower, may be seen *Etanin* and three other stars in the head of the Dragon.

The CUP and the CROW, with the constellation of the WATER-SERPENT (Plate XIV.), occupy a large space from S. to S. E. by E.

Below Boötes is seen a part of HERCULES (Plate VII.).

*Sirius*, in the GREAT DOG (Plate XIII.), about 25 degrees high, is nearly in the S. W. On each side, and at nearly equal distances from it, are two stars, one in his foot, the other in the neck.

The Little Dog (Plate VI.) is more to the S., about 26 degrees higher.

*Castor* and *Pollux*, in the Twins (Plate VI.), are about 70 degrees high, W. S. W. The foot of Pollux is about 50 degrees high.

Orion (Plate VI.), occupies the space between W. by S., and S. W. by W. *Rigel*, in the heel, is about 9 degrees high; and *Betelguex*, in the shoulder, is about 27 degrees high.

Between Betelguex and Castor and Pollux are four stars, forming an imperfect square in the feet and knees of the Twins.

Sirius and Betelguex form nearly an equilateral triangle with *Procyon*, in the Little Dog.

The Unicorn (Plate VI.) is between Sirius and Procyon.

*Aldebaran*, in the Bull (Plate VI.), is due W., about 28 degrees high; and the south horn is about 41 degrees high: these two stars and Betelguex form a triangle. The northern horn of the Bull is about 17 degrees above Aldebaran.

*Capella*, or *Alioth*, in the Charioteer (Plate VI.), is about 48 degrees high, W. N. W.

*Algol*, in Medusa's Head (Plate IV.) is about 24 degrees high, N. W. by W.

Perseus (Plate IV.) is a few degrees higher.

Andromeda (Plate V.) and Cassiopeia (Plate IV.) are more to the north.

## APRIL.

*Middle of the Month, about half-past Nine o'clock.*

The GREAT BEAR (Plate IV.) is on the meridian, a little N. of the zenith; the lower star in the tail (one of those called *Charles's Wain*) is about 62 degrees high.

Below the hind foot of the Bear, the fourth star on the back of the LION (Plate VIII.) is on the meridian, about 72 degrees high.

*Deneb*, or *Arided*, in the SWAN, (Plate III.) is about 2 degrees high, N. N. E.

A line drawn from Deneb northwards to the LITTLE BEAR, will pass through the DRAGON (Plate III.).

*Vega*, in the LYRE (Plate VII.), is between N. E. and N. E. by E., about 10 degrees high.

A line carried from Vega towards the body of Charles's Wain, will pass nearly by the two stars in the head of the Dragon; and, 30 degrees higher, the principal star in that constellation is seen.

Two stars in the E. by N., one about 5 degrees, the other about 10 degrees high, are *Ras Alhague*, in the head of the SERPENT-BEARER (Plate IX.); and *Ras Algethi*, in the head of HERCULES (Plate VII.).

*Alphecca*, in the NORTHERN CROWN (Plate VII.), is E. by N., about 36 degrees high.

E. by S., extending from the horizon to 30 degrees high, is a part of the constellation SERPENT (Plate IX.).

*Arcturus,* in Boötes (Plate VII.), is about 46 degrees high, E. by S.; and about 26 degrees higher is Charles's Heart (Plate III.).

The Scales (Plate IX.) is more to the S., about 15 degrees above the horizon.

*Spica,* in the Virgin (Plate VIII.), is in the S. E. by S., about 32 degrees high; and, 23 degrees higher, is *Vindemiatrix,* in the arm of the same constellation.

Berenice's Hair (Plate VIII.) is about 70 degrees high, a little more to the E.

The upper part of Centaurus (Plate XIV.) is just above the horizon, in the S. E. by S.

*Denebola,* in the tail of the Lion (Plate VIII.), is between S. S. E. and S. by E., about 65 degrees high. Cor Leonis, or Regulus, is about 60 degrees high, S. S. W.

A line carried from Denebola to the horizon will pass through the head of the Virgin, and through the Crow and the Water-Serpent.

*Cor Hydræ* (Plate XIV.) is in the same azimuth, about 37 degrees high.

The Little Dog (Plate VI.) is W. S. W.; and the Unicorn (Plate VI.) below him.

*Sirius* is a little more to the S., 7 degrees high.

*Betelguex,* in Orion (Plate VI.), is due W., about 12 degrees high.

*Castor,* in the Twins (Plate VI.), is about 47 degrees high.

*Aldebaran,* in the Bull (Plate VI.), is more to the N., about 4 degrees high. The northern horn

of the Bull is between W. N. W. and W. by N., about 21 degrees high.

*Capella*, or *Alioth*, in the CHARIOTEER (Plate VI.), is N. W. by W., 27 degrees high; and the second star in this constellation is about 34 degrees high.

*Algenib*, in PERSEUS (Plate IV.), is between N. W. by N. and N. W., about 13 degrees high.

*Algol*, in MEDUSA'S HEAD (Plate IV.), is about 7 degrees high.

CASSIOPEIA (Plate IV.) is in N. by W.

---

## MAY.

*Middle of the Month, about half-past Nine o'clock.*

COR CAROLI is in the zenith.

*Mizar*, the middle star in the tail of the GREAT BEAR (Plate IV.), is on the meridian, and 15 degrees N. of the zenith.

*Spica* and Vindemiatrix, in the VIRGIN (Plate VIII.), are near the meridian; the former 40, and the latter 62, degrees high.

CEPHEUS (Plate III.) is in the N. N. E. *Alderamin*, the principal star in Cepheus, is about 22 degrees high. A line drawn from Cepheus towards the zenith, will pass near the LITTLE BEAR (Plate III.).

*Deneb*, or *Arided*, in the SWAN (Plate III.), is in the N. E., about 13 degrees high.

*Vega*, in the LYRE (Plate VII.), is about 30 de-

grees high, E. N. E.; and *Albiero*, in the beak of the Swan, is about 15 degrees below it.

The stars in the body of the DRAGON (Plate III.), are between Cepheus, the Swan, the Lyre, and the Little Bear. The stars in the head of the Dragon are N. E. of Vega, and about 40 degrees high.

*Ras Alhague*, in the SERPENT-BEARER (Plate X.), is due E., about 27 degrees high; and *Ras Algethi*, in HERCULES (Plate VII.), a little more to the S., about 32 degrees high.

The NORTHERN CROWN (Plate VII.) is about 58 degrees high, in E. by S.

The SERPENT (Plate IX.) is more to the S., and extends from 50 degrees to the horizon.

The two stars in the shoulders of BOÖTES (Plate VII.) are nearly in a line, towards the zenith, with *Gemma*, in the Northern Crown.

The SCALES (Plate IX.) occupy the space from S. S. E. to S. E.

*Arcturus*, in Boötes, is about 66 degrees high, S. E. nearly.

*Algenib*, in PERSEUS (Plate IV.), is about 5 degrees high, in N. N. W.

*Capella*, in the CHARIOTEER (Plate VI.), is 9 degrees high, in N. W. by N.; and the star in his shoulder 16 degrees high.

*Dubhe*, in the GREAT BEAR (Plate IV.), is a little more N., about 60 degrees high; and the whole of this constellation is now in a favourable position for observation.

*Castor* and *Pollux*, in the TWINS (Plate VI.), are W. N. W., about 24 degrees high.

*Procyon*, in the LITTLE DOG (Plate VI.), is due W., about 9 degrees high. The CRAB (Plate VI.) is above it.

The LION (Plate VIII.) occupies the space between W. by S. and S. W. by S. *Denebola*, in the tail, is 60 degrees high; and *Cor Leonis*, or *Regulus*, is about 42 degrees high.

*Cor Hydræ*, or *Alphard* (Plate XIV.), is about 23 degrees below Regulus, and about 20 above the horizon. The whole of the Hydra may now be seen, extending from the stars in the head, in W. by S. to S. S. E. It occupies nearly a horizontal line, under the Lion and Virgin, of almost 90 degrees.

In the intermediate space, three more constellations are supported on the Hydra, viz.: the SEXTANT, under the Lion; the CUP, under the Lion and Virgin; and the CROW, between the southern wing of the Virgin and the tail of the Hydra.

BERENICE'S HAIR (Plate VIII.) is seen between the Virgin and Cor Caroli.

## JUNE.

*Middle of the Month, about Ten o'clock.*

The LITTLE BEAR (Plate III.) is on the meridian; and *Alruccaba*, the *Pole-star*, may be easily discovered at the end of his tail, the body of the Bear being above the Pole.

The NORTHERN CROWN (Plate VII.) is also on the meridian, about 80 degrees high, or 10 degrees south of the zenith; and the head of the SERPENT (Plate IX.) about 10 degrees lower.

Half-way between the Pole-star and the N. N. E. point of the horizon is CASSIOPEIA (Plate IV.), the principal stars of which, five in number, appear like an inverted chair. *Schedir*, the principal star, is about 13 degrees high.

*Alderamin*, in CEPHEUS (Plate III.), is in the N. E. by N., about 37 degrees high; and the three stars in his crown are 10 degrees lower.

*Scheat*, in PEGASUS (Plate V.), is about 6 degrees high. A line drawn from this star to the head of Cepheus, will pass through the LIZARD (Plate III.).

*Deneb*, or *Arided*, in the SWAN (Plate III.), is about 36 degrees high, in N. E. by E.

The stars in the head of the DRAGON (Plate III.) are in the N. E., 65 degrees high.

Nearly due E., about 22 degrees high, is the DOLPHIN (Plate IX.); 42 degrees high, is *Albiero*, in the beak of the SWAN; and, 57 degrees high, *Vega*, in the LYRE (Plate VII.).

*Atair*, in the EAGLE (Plate IX.), is 27 degrees high, E. by S. nearly.

ANTINOUS (Plate IX.) is more to the S.; and the three stars in his foot are about 25 degrees high.

*Ras Algethi*, in HERCULES (Plate VII.), is about 58 degrees high, and the whole of the constellation extends nearly to the zenith.

*Ras Alhague*, in the SERPENT-BEARER (Plate IX.), is 55 degrees high, and the constellation occupies the space from S. E. to S.

*Antares*, in the SCORPION (Plate X.), is 22 degrees high, S. by E., below the foot of the Serpent-Bearer. Antares forms a large triangle, with Arcturus and Spica Virginis westward, and with Vega eastward.

PONIATOWSKI'S BULL (Plate VII.) is between the Eagle and Serpent-Bearer; CERBERUS (Plate VII.) is above Poniatowski's Bull; and the ARCHER is near the horizon, below the Serpent-Bearer.

PERSEUS (Plate IV.) is in the N., partly above the horizon; and between this constellation and the Pole-star is the CAMELEOPARD (Plate IV.).

*Dubhe*, in the GREAT BEAR (Plate IV.) is 44 degrees high, N. W.

*Cor Leonis*, in the LION (Plate VIII.), is nearly due W. 14 degrees high; the hind-foot of the Great Bear 32 degrees high; and *Benetnasch*, in the tail of the Bear, 68 degrees high.

COR CAROLI (Plate III.) is 60 degrees high, nearly W. by N.

*Denebola*, in the tail of the LION, is 36 degrees high.

BERENICE'S HAIR (Plate VIII.) is 50 degrees high, between W. by S. and W.

The VIRGIN (Plate VIII.) occupies the space from W. S. W. to S. S. W.; *Vindemiatrix* is about 48 degrees high, in S. W. by W.; and *Spica* between S. W. and S. W. by S. 32 degrees high.

*Arcturus*, in Boötes (Plate VII.), is in the S. W., and its altitude is 65 degrees. *Alkalurops*, in his head, is nearly in the zenith.

The chief star in the Scales (Plate IX.) is between S. S. W. and S. by W. 25 degrees high.

Below the Scales is the Owl; and below that is the Wolf, in the meridian. N. W. of the Wolf is the head of the Centaur.

The Cup, the Crow, and the tail of the Hydra (Plate XIV.), are under the Virgin.

---

## JULY.

*Middle of the Month, about Three-Quarters past Nine o'clock.*

The head of the Dragon (Plate III.) is on the meridian, and 12 degrees N. of the zenith.

A line drawn from Etanin to the N. E. on the horizon, will pass *Alderamin*, in Cepheus (Plate III.), 48 degrees high; the three stars in his head, 40 degrees high; and by *Mirach*, the second star in Andromeda (Plate V.), about 16 degrees high.

Cassiopeia (Plate IV.), whose stars form a *W*, is N. E. by N. between 20 and 30 degrees high.

Perseus (Plate V.) is in the N. N. E.; *Algenib*, in his side, is about 4 degrees high. The third star $\gamma$ in Perseus is about 9 degrees high.

*Alamak*, in the foot of Andromeda, is in the N. E. by N., the same altitude as Algenib, in Perseus; and E. N. E. 12 degrees high, is *Alpheratz*, in the head of Andromeda.

Algenib, in Perseus, Alamak, Mirach, and the star in the head of Andromeda, form a line nearly parallel with the horizon.

*Algenib*, in the wing of PEGASUS (Plate V.), is in the horizon E. by N. nearly; *Scheat*, 23; and *Markab*, E. by N. about 14 degrees high.

These three stars and Alpheratz, in the head of Andromeda, form a large square.

About 37 degrees high, nearly due E., is seen a star in the extremity of the southern wing of the SWAN (Plate III.); and at 54 degrees high, *Deneb*, or *Arided*. The extremity of the upper wing is about 66 degrees high.

The LIZARD (Plate III.) is between the Swan, Cepheus, Andromeda, and Pegasus.

*Enir*, in the mouth of PEGASUS (Plate V.), is E. by S. about 26 degrees high.

The DOLPHIN (Plate IX.) is E. S. E. 40 degrees high.

*Altair*, in the EAGLE (Plate IX.), is S. E. and S. E. by S. about 45 degrees high.

*Albiero*, in the beak of the SWAN (Plate III.), is 62 degrees high, and *Vega*, in the LYRE (Plate VII.), is due E. about 77 degrees high.

The Fox and GOOSE (Plate IX.) are between Albiero and Altair.

The ARCHER (Plate X.), the GOAT (Plate XI.), and the WATER-BEARER (Plate XI.), occupy the space from S. to E. S. E.

The two principal stars in the Goat are about

22, and the two principal stars in the Water-Bearer about 15 degrees high.

The GREAT BEAR (Plate IV.) is in the N. W., and a line drawn through the upper *Pointer* to the zenith will pass through the star of DRACO (Plate III.), which is midway between the two principal stars in the square of Ursa Minor, and the second in the tail of Ursa Major.

CHARLES'S HEART (Plate III.) is 41 degrees high, W. N. W.

*Denebola*, in the LION (Plate VIII.), is 15 degrees high, W. by N.

BERENICE'S HAIR (Plate VIII.) is 30 degrees high, in the same azimuth.

*Vindemiatrix*, in the VIRGIN (Plate VIII.), is 28 degrees high, nearly due W.; and *Spica*, W. S. W. 16 degrees above the horizon.

The southern shoulder of BOÖTES (Plate VII.) is due W. 65 degrees high; the northern nearly W. by N. 58 degrees high; and *Arcturus* about 47 degrees high.

The NORTHERN CROWN (Plate VII.) is W. S. W. nearly 65 degrees high.

The southern star in the SCALES (Plate IX.) is 25 degrees high, S. W. by S. nearly; and the northern star 34 degrees.

*Antares*, or *Cor Scorpionis*, in the SCORPION (Plate X.), is 23 degrees high, S. S. W.

A line drawn from Antares to the zenith will pass through the SERPENT-BEARER (Plate IX.), and HERCULES (Plate VII.), which are a little W.

of the meridian. *Ras Alhague* and *Ras Algethi* are on opposite sides of the meridian, 65 degrees high.

---

## AUGUST.

*Middle of the Month, about Ten o'clock.*

*Capella*, in the Charioteer (Plate VI.), is between N. E. by N. and N. N. E. 3 degrees high.

Perseus (Plate IV.) is in the N. E. *Algol*, in Medusa's Head, called the second in Perseus, is about 12 degrees high.

Cassiopeia (Plate IV.) is above Perseus, about 40 degrees high.

*Alamak*, in the foot of Andromeda (Plate V.), is 22 degrees high, N. E. by E. nearly. *Mirach* is 27 degrees high in E. by N.; and the first star in Andromeda, E. by N. about 35 degrees high.

The two stars in the head of the Ram (Plate V.) are seen below Mirach, about 15 degrees high.

The Triangles (Plate V.), and the Fly (Plate V.), are between the Ram and Andromeda.

The three stars in Pegasus (Plate V.), which, with the one in the head of Andromeda, form a square, are in a favourable situation for observation. *Algenib*, the third, is due E. 26 degrees high; *Markab*, the first, E. S. E. nearly, is 39 degrees high; and *Scheat*, the second, is due E. 48 degrees high. *Enir*, in the mouth of Pegasus, is about 49 degrees high, S. E.

A line drawn from S. E. by E. to the zenith, will pass some stars in the neck of Pegasus; and at 63 degrees will pass a star in the tip of the wing of the SWAN (Plate III.); and *Deneb*, or *Arided*, the principal star in that constellation, is 77 degrees high, the northern wing being in the zenith.

*Scheat*, in the leg of the WATER-BEARER (Plate XI.), is S. E. about 18 degrees high: about 38 degrees high is the principal star in this constellation; and 37 degrees high, is the second in his left shoulder.

The DOLPHIN (Plate IX.) is 62 degrees high, S. S. E.

The FOX (Plate IX.) is about 10 degrees higher.

The two stars in the GOAT (Plate XI.) are S. by E. about 35 degrees high.

*Altair*, in the EAGLE (Plate IX.), is on the meridian, 59 degrees high; *Albiero*, in the beak of CYGNUS (Plate III.), 20 degrees higher.

CEPHEUS (Plate III.) is in the N. E. above Cassiopeia; and between Pegasus, Andromeda, Cassiopeia, Cepheus, and the Swan, the LIZARD (Plate III.) is seen, E. N. E.

The ARCHER (Plate X.) occupies a space between S. and S. S. W. Some degrees higher are SOBIESKI'S SHIELD and PONIATOWSKI'S BULL (Plate VII.).

10 degrees above the horizon, *Antares*, in the SCORPION (Plate X.), is seen S. W.; about 52 degrees high, *Ras Algethi*, in HERCULES (Plate VIII.),

and *Ras Alhague*, in the SERPENT-BEARER (Plate IX.); and about 30 degrees higher, near the zenith, is *Vega*, in the LYRE (Plate VII.).

The second star of the SCALES (Plate IX.) is W. S. W. 13 degrees high; above which, more to the W., are some stars in the head of the SERPENT (Plate IX.).

The NORTHERN CROWN (Plate VII.) is nearly due W.

*Arcturus*, in BOÖTES (Plate VII.), is 20 degrees high, W. by N.; 20 degrees higher, the star in the right shoulder of Boötes. A line drawn from the last star towards the zenith, will pass a little S. of the leg of HERCULES (Plate VII.) and the stars in the head of the DRAGON (Plate III.).

BERENICE'S HAIR (Plate VIII.) is N. W. by W., just above the horizon.

CHARLES'S HEART (Plate III.) is 18 degrees high, in the same azimuth, surrounded by the stars in the HOUNDS.

Above Charles's Heart is *Benetnasch*, in the tip of the tail of the GREAT BEAR (Plate IV.); and a little above it, are three stars, near the hand of BOOTES (Plate VII.).

The GREAT BEAR is 20 degrees high, N. N. W., and *Kochab*, one of the guards in the LITTLE BEAR (Plate III.), is 44 degrees high · the Pole star is to the E. of it.

## SEPTEMBER.

*Middle of the Month, about Ten o'clock.*

The LYNX (Plate V.) occupies the space comprehended between N. E. by N. to N. by E., with his head 17 degrees above the horizon.

The CAMELEOPARD (Plate IV.) is above the Lynx, extending from N. E. to the Pole.

*Capella*, in the CHARIOTEER (Plate VII.), is in the N. E., 14 degrees high; and his companion, the second in the Charioteer, is a few degrees lower, towards the N.

The north horn of the BULL (Plate VI.) is in the N. E. by E., about 4 degrees high. About 30 degrees higher is seen *Algenib*, in PERSEUS (Plate IV.); and CASSIOPEIA (Plate IV.) is still higher, and more to the N.

*Aldebaran*, in the Bull, is rising, with the HYADES, E. N. E.; the PLEIADES are about 17 degrees high, more to the E.

The foot of PERSEUS (Plate IV.) is to the N. E. of the Pleiades; and *Algol*, in the HEAD of MEDUSA, about 10 degrees higher.

*Alamak*, in ANDROMEDA, (Plate V.), is E. N. E., 43 degrees high; below which are the TRIANGLES (Plate V.), the FLY, and the tail of the RAM (Plate V.). *Arietis*, the northern horn of the Ram, nearly due E., is about 33 degrees high.

*Mirach*, in Andromeda, is 50 degrees high; the star in the hand, towards the zenith, is 63 degrees

high. The head of Andromeda is nearly E. by S., 58 degrees high.

*Menkar*, in the WHALE (Plate XII.), is about 10 degrees high, under Arietis. This constellation occupies a space from E. to S. E. by S., and nearly 30 degrees from the horizon.

*Algenib*, in PEGASUS (Plate V.), is S. E. by E.; *Scheat*, 70 degrees high; and *Markab*, 58 degrees.

The four last-mentioned stars form a conspicuous square.

*Fomalhaut*, in the SOUTHERN FISH (Plate XI.), is about 17 degrees high, S. by E. nearly.

*Scheat*, in the WATER-BEARER (Plate XI.), is more to the E. and higher. The greater part of this constellation is on or near the meridian.

*Enir*, in the mouth of PEGASUS (Plate V.), is on the meridian, 60 degrees high; and, about 20 degrees higher, is the star in the southern wing of the SWAN (Plate III.).

The head of CEPHEUS (Plate III.) is 20 degrees N. of the zenith.

Two stars in the head of the GOAT (Plate XI.) are 32 degrees high; those in his tail are more to the S.

The DOLPHIN (Plate IX.) is in the same azimuth, 60 degrees high.

ANTINOUS (Plate IX.) is S. W. by S. The star in his knee is 35 degrees high.

*Altair*, in the EAGLE (Plate IX.), is 50 degrees

high, in the same azimuth; and the two stars in the tail of the Eagle are in the same altitude, S. W. by W.

Below the tail of the Eagle is the BULL OF PONIATOWSKI (Plate VII.); above it is *Albiero*, in the beak of the SWAN (Plate III.); and almost in the zenith is *Deneb*, or *Arided*, in the same constellation.

*Ras Alhague*, in the head of the SERPENT-BEARER (Plate IX.), and *Ras Algethi*, in the head of HERCULES (Plate VII.), are W. by S., nearly 30 degrees high.

*Vega*, in the LYRE (Plate VII.), is a little more to the W., 57 degrees high; above which is the northern wing of the SWAN (Plate III.).

The head of the SERPENT (Plate IX.), is 12 degrees high, W. by N.; and at the same elevation, more to the N., *Mirach*, in the girdle of BOÖTES (Plate VII.), is observed.

*Alphecca Gemma*, in the NORTHERN CROWN (Plate VII.), is 15 degrees high, between Boötes and Hercules; and rather higher, towards the N., are the stars in the shoulders of Boötes. In the N. W., 50 degrees high, are the stars in the head of the DRAGON (Plate III.).

CHARLES'S HEART (Plate III.) is 2 degrees high, N. W. by N.; and the tail of the GREAT BEAR (Plate IV.) is seen some degrees above it. A line drawn from *Alioth*, in the tail, to the zenith, will

pass the principal stars in the Dragon and the Great Bear.

The GREAT BEAR (Plate IV.) occupies the lowest part of the northern region.

---

## OCTOBER.

*Middle of the Month, about Ten o'clock.*

*Castor* and *Pollux*, in the TWINS (Plate VI.), are just in the horizon, in N. E.; and *Orion* in the E.

*Capella* and its companion, in the CHARIOTEER (Plate VI.), are N. E. by E.; the former 32 degrees high, the latter 25.

The foot of CASTOR is in the horizon, E. N. E. The N. horn of the BULL (Plate VI.) is more to the E., 23 degrees high; PERSEUS (Plate IV.) is still higher; and CASSIOPEIA (Plate IV.) near the meridian, 15 degrees below the zenith.

*Aldebaran*, in the BULL (Plate VI.), is 23 degrees high, due E.

*Algol*, in the HEAD of MEDUSA (Plate IV.), 30 degrees higher.

The PLEIADES (Plate VI.) are 37 degrees high.

*Menkar*, in the mouth of the WHALE (Plate XII.), about 33 degrees high, E. S. E. nearly.

*Arietis*, the northern horn of the RAM (Plate V.), is 55 degrees high.

Between the Ram and the Head of Medusa are the TRIANGLES (Plate V.), and the FLY (Plate V.).

*Mirach*, in ANDROMEDA (Plate V.), is 73 degrees

high. *Alpheratz*, the head of Andromeda, is 78 degrees high, very near the meridian.

*Algenib*, in PEGASUS (Plate V.), is about 62 degrees high; *Scheat* and *Markab* have just passed the meridian. The whole of Pegasus extends from S. by E. to S. W. by S.

*Fomalhaut*, in the SOUTHERN FISH (Plate XI.), is S. by W.

The WATER-BEARER (Plate XI.) is S. S. W.; the star in his right shoulder is 44 degrees high, that in his left 26.

The principal stars in the GOAT (Plate XI.) are 20 degrees high, S. W.

The DOLPHIN (Plate IX.) is 44 degrees high, W. S. W.

*Altair*, in the EAGLE (Plate IX.), 30 degrees high, W. by S.

The SWAN (Plate III.) is nearly due W. *Albiero*, in its beak, 38 degrees high; and *Deneb*, or *Arided*, 58.

*Vega*, in the LYRE (Plate VII.), is nearly in the same altitude as Albiero, W. by N.

*Etanin*, in the DRAGON (Plate III.), 33 degrees high, N. W.

The GREAT BEAR (Plate IV.) is in the lower part of the N.

*Ras Algethi*, in HERCULES (Plate VII.), and *Ras Alhague*, in the SERPENT-BEARER, are just above the horizon, between W. by N. and W. N. W.

## NOVEMBER.

*About the Middle of the Month, at Ten o'clock.*

The GREAT BEAR (Plate IV.) occupies the space included between the N. E. and N. *Dubhe* is N. N. E., 18 degrees high. In the same azimuth, 30 degrees high, are the stars in the head. To the N. of N. E. is a star in the fore leg, in a line with Dubhe: and 14 degrees below it, are two stars in the upper hind paw. The fore paws are in the N. E.

The LITTLE LION (Plate IV.) is below the Great Bear, from N. E. to N. E. by N.

The CAMELEOPARD (Plate IV.) occupies the space above the Great Bear to the meridian.

*Castor* and *Pollux*, in the TWINS (Plate VI.), are E. N. E.; the first 22 degrees high, the last 18 degrees high.

More to the E. and at 45 degrees high, is the second star in the shoulder of the CHARIOTEER (Plate VI.); and a few degrees higher is *Capella*, or *Alioth*.

Nearly due E. are *Procyon*, in the LITTLE DOG (Plate VI.), the feet of the TWINS (Plate VI.), the Northern horn of the BULL (Plate VI.), and the constellation PERSEUS (Plate IV.).

Between the Charioteer, the Great Bear, the Little Lion, and the Twins, is the constellation LYNX (Plate VIII.).

*Betelguex* and *Bellatrix*, in the shoulders of

ORION (Plate VI.), are seen about 28 degrees high, E. S. E. *Rigel*, in the heel, is 22 degrees high, S. E. by E.

The *Hyades*, in the BULL (Plate VI.), are about 45 degrees high, and the *Pleiades* about 59. The Hyades rise acronycally in the beginning of this month, as do also the Pleiades, which have been called the heralds of Winter.

Two stars in the foot of PERSEUS (Plate IV.) are about 65 degrees high; and *Algol*, in MEDUSA'S HEAD, is about 75.

The third star in the RIVER PO (Plate XII.) is S. E. by S. 27 degrees high.

*Menkar*, in the WHALE (Plate XII.), is S. S. E.; 50 degrees high, and the constellation extends to S. S. W.

The RAM (Plate V.) is above the Whale; and the stars in the head are nearly on the meridian.

*Alamak*, in ANDROMEDA (Plate V.), is in the zenith.

*Alpheratz*, in the head of ANDROMEDA (Plate V.), is S. W. 60 degrees high; and the three conspicuous stars in PEGASUS (Plate V.) are below it; *Algenib* is to the S., *Scheat* to the W., and *Markab*, the lowest, forming a triangle with the two last.

The FISHES (Plate V.) are now visible; one under Mirach, in Andromeda; the other under Markab, in Pegasus.

The WATER-BEARER (Plate XI.) is S. W. by W.; his water-pot is 25 degrees above the horizon, and 20 degrees below Markab.

*Enir*, in the mouth of PEGASUS (Plate V.), is 30 degrees high; and below it is the LITTLE HORSE.

The DOLPHIN (Plate IX.) is due W. 20 degrees high; and the extremity of the wing of the SWAN (Plate III.) is 20 degrees higher.

The EAGLE (Plate IX.) is near the horizon.

The SWAN is W. N. W. *Albiero*, in the beak, is 15 degrees high; the third is 32 degrees high: *Deneb*, or *Arided*, is 37 degrees high; and the northern wing extends to N. W.

*Vega*, in the LYRE (Plate VII.), is between N. W. by W. and N. W. 12 degrees high.

CEPHEUS's shoulders (Plate III.) are 44 and 54 degrees high.

*Etanin*, in the DRAGON (Plate III.), is 15 degrees high, N. W. by N. nearly; and the greater part of this constellation is between that star and the Little Bear, which is now below the Pole star.

---

## DECEMBER.

*Middle of the Month, about Ten o'clock.*

The body of the LITTLE BEAR (Plate III.) is upon the meridian, below the Pole star. A few degrees from it, towards the E., is seen the first star of the DRAGON.

The tail of the GREAT BEAR (Plate IV.) is N. N. E.

The LITTLE LION (Plate IV.) is between E. N. E. and N. E. by E.

*Cor Leonis*, or *Regulus*, in the LION (Plate VIII.), is E. by N. about 8 degrees high; and more to the N. and higher, the stars in the head and neck are seen; his paws are due E.

The head of the HYDRA (Plate XIV.) is due E. about 15 degrees high. A line drawn from it to *Castor*, in the TWINS (Plate VI.), 45 degrees high, will pass the CRAB (Plate VI.). *Pollux* is a few degrees below Castor.

*Procyon*, in the LITTLE DOG (Plate VI.), is between E. S. E. and E. by S. 28 degrees high. A line drawn from this star to the zenith will pass near the feet of the Twins. *Capella*, in the CHARIOTEER (Plate VI.), is 15 degrees below the zenith.

The UNICORN (Plate VI.) is below Canis Minor.

*Sirius*, in the GREAT DOG (Plate XIII.), between S. E. and S. E. by S. is about 20 degrees high. A line drawn from it to the zenith, at 48 degrees high, will pass near Betelguex in Orion's shoulder.

*Rigel*, in ORION'S heel (Plate VI.), S. S. E., is 37 degrees high.

The HARE (Plate XII.) is below Orion.

*Aldebaran*, in the BULL (Plate VI.), is approaching the meridian: the PLEIADES are on it.

PERSEUS (Plate IV.) is in the zenith.

The RIVER PO (Plate XII.) occupies the southern region, extending from Orion to the Whale.

*Menkar*, in the WHALE (Plate XII.), is nearly 52 degrees high, S. S. W. nearly; his tail is S. W.

A line drawn to the zenith will pass the head of

the RAM (Plate V.) between the TRIANGLES (Plate V.) and the FLY (Plate V.), and by the HEAD of MEDUSA (Plate IV.).

*Markab*, in PEGASUS (Plate V.), is nearly due W. 25 degrees high.

The head of ANDROMEDA (Plate V.) is 46 degrees high; *Mirach*, 61; *Alamak*, 72.

CASSIOPEIA (Plate IV.) is between 50 and 60 degrees, N. W. by W.

SWAN (Plate III.) is N. W. *Deneb*, or *Arided*, 19 degrees high.

The head of CEPHEUS (Plate III.) is 20 degrees higher; and the whole of this constellation extends to the Pole star.

The greater part of the DRAGON (Plate III.) occupies the space from N. N. W. to the Little Bear.

---

## SEC. 13.

### DESCRIPTION OF THE PLATES OF THE TELESCOPIC APPEARANCE OF THE DOUBLE STARS.

Fig. 1. $\alpha$ Geminorum or Castor. R. A. 110° 43′, Dec. 32° 15′. This double star consists of two stars of the 3d and 4th magnitudes, of a greenish colour. Through ordinary telescopes they appear to be in contact, since their distance is only 5″. In better telescopes they appear well divided. It has been found that these stars revolve round each other in a period of 232 years in an

elliptical orbit, whose greater axis is 14″, and whose eccentricity is 0.8.

Fig. 2. $\gamma$ Virginis. R. A. 188° 15′, Dec. 0° 29′, south. In this pair of stars also, both are of the 3d magnitude, and their distance is only 2″. The period of their revolution is 145 years in an elliptical orbit, of which the major axis is 7″, and the eccentricity 0.9. These two stars appear in good telescopes as beautiful objects, sharply defined. Both stars are of a light yellowish colour. (See page 95.)

Fig. 3. $\zeta$ Ursæ Majoris, or Mizar, the middle star in the tail of the Great Bear. R. A. 199° 15′, Dec. 55° 41′; of the 3d and 4th magnitudes; distant 14″. Easily divided with smaller telescopes. Both of greenish white.

Fig. 4. $\alpha$ Herculis. R. A. 256° 30′, Dec. 14° 36′; 3d and 7th magnitudes; distant 5″. The greater bright yellow, and the smaller deep blue.

Fig. 5. $\gamma$ Leonis; 2d and 4th magnitudes; distant $2\frac{1}{2}$″. The greater gold yellow, the smaller greenish purple. The most splendid double star in the northern hemisphere, both in brightness and contrast of colours.

Fig. 6. $\gamma$ Andromeda or Alamak. R. A. 28° 15′, Dec. 41° 30′; 3d and 5th magnitudes; distant 10″. The greater orange, the smaller emerald green. The colours are very distinct; a beautiful object.

Fig. 7. $\beta$ Orionis or Rigel. R. A. 76° 30′, Dec. 8° 25′, south; 1st and 8th magnitudes; distant 10″. Colour yellowish white.

Fig. 8. $\gamma$ Arietis or Mesarthim. R. A. 26° 0′, Dec. 18° 27′; both of the 4th magnitude; distant 9″; very white.

Fig. 9. $\alpha$ Ursæ Minoris or Polaris. For the year 1844, R. A. 15° 45′, Dec. 88° 20′; 2d and 9th magnitudes; distant 18″. The greater is yellow, the smaller white.

Fig. 10. A double star, near the head of the southern Grey-hound. R. A. 181° 48′, Dec. 41° 36′; 5th and 8th magnitudes; distant 11″. The greater is a beautiful gold yellow, the smaller blue.

Fig. 11. $\alpha$ Lyræ or Vega. R. A. 277° 45′, Dec. 38° 37′; 1st and 11th magnitudes; distant 43″.

## SEC. 14.

### PORTIONS OF THE HEAVENS RICH IN STARS.

These are portions in which many stars appear to the naked eye, collected in a small space, which are not so dense as to be synonymous with clusters or groups of stars, in the strictest sense of the word.

Fig. 12. The Pleiades or the Seven Stars, called also the Clucking-hen, on the neck of the

Bull. With unassisted eyes we can distinguish the larger stars of this collection.

Fig. 13. The Hyades, upon the forehead of the Bull, of which the principal stars form a V.

Fig. 14. The Crib in Cancer, or Præsepe, visible to the naked eye; but through a telescope, even of small magnifying power, a very remarkable accumulation of many stars upon a space of about three-fourths of a degree square: midway between $\gamma$ and $\delta$, or Asellus Borealis and Asellus Australis.

Fig. 15. Another accumulation of stars, all large, between the ends of the Bull's horns, or between $\beta$ and $\zeta$ Tauri. The rings represented in this figure with three or four small crosses, denote separate groups of stars or collections of many small and thickly clustered stars, which can only be recognised through very good telescopes, and of which an account will be found on the next page.

Fig. 16. Another still more rich portion, in stars encompassing the whole constellation of Lyra.

Fig. 17. This is likewise a spot, around the star Arcturus in Boötes, studded with many small stars.

Fig. 18. Represents the neighbourhood of the remarkable nebula of Orion, abounding in small stars.

## SEC. 15.

### CLUSTERS OF STARS.

By this name is to be understood a great cluster of small stars, collected together upon a very small space, which are invisible to the naked eye, and, even with ordinary telescopes, appear only as a light cloud; but resolvable, with more powerful telescopes, into small stars. Those parts of the heavens which, even through the most perfect telescopes, appear as light clouds, not resolvable into stars, are called nebulæ. These last are contained in the next plate of this collection. It may here be remarked, that the number of these nebulæ, many of which perhaps are nothing else than very distant groups of stars, is very great in some parts of the heavens.

Fig. 19. In the northern wing of the Virgin is a space of 10° R. A. and Dec., which contains over a hundred such nebulæ. The plate contains only the largest and most remarkable of the groups of stars.

Fig. 20. A very rich group of stars, between $\eta$ and $\varepsilon$ Herculis. R. A. 248° 45′, Dec. 36° 48′. It is of an irregular form, scolloped, as it were, about the edge; and, although the stars of which it is composed appear more condensed toward the middle, yet the group has no proper nucleus. The number of stars in this group which are distinctly visible, exceeds a hundred; but, towards the much

brighter middle, they are innumerable.—Those which are visible, are nearly all of the 9th to the 11th magnitudes.

Fig. 21. A gorgeous group of stars in Berenice's Hair; the foregoing (Fig. 20) is not unlike it in the exterior form. R. A. 196° 0′, Dec. 19° 4′. Its apparent diameter is from 5 to 6 minutes, and it contains a truly countless multitude of very densely-clustered stars, of the 10th to the 12th magnitudes. The elder Herschel pronounced this group the most gorgeous object which he had seen in the heavens.

Fig. 22. A large, round, beautiful group in Aquarius, almost entirely resolvable into stars, with very good telescopes. R. A. 321° 15′, Dec. 1° 34′, south. Toward the middle it appears very bright, and as it were flaming, when viewed through the telescope. According to the younger Herschel's expression, it is like a globular heap of gold sand. The middle and brightest part of the whole is 6″ in diameter, and is very similar to a star of the 6th magnitude.

Fig. 23. A beautiful and very crowded group of stars in Libra, of a spherical form. R. A. 227° 30′, Dec. 2° 44′. Its light increases towards the middle very rapidly, and there the individual stars of which the group consists, cannot be separated. The diameter

of the whole is $2\frac{1}{2}'$, and the neighbourhood around this group is entirely void of stars.

Fig. 24. The magnificent group of stars in Capricornus. R. A. 311° 0′, Dec. 13° 13′, south. It is round, and very brilliant. The stars are more crowded towards the centre, but with good telescopes can be separated. It contains more than a thousand fixed stars.

Fig. 25. A large, fan-shaped, out-spread group of stars. R. A. 101° 18′, Dec. 18° 14′. Towards the end, the light increases rapidly, and opposite this end the border appears torn and badly defined. Length and breadth of the whole, about 6′.

Fig. 26. An elongated group, between α and A in the Crab, rounded on one side, and pointed upon the other. R. A. 129° 30′, Dec. 13° 13′. The small, very much crowded stars appear as if lying about a light central body, and the whole group rests upon a nebulous ground.

Fig. 27. A large, rich group of stars in Ophiuchus. R. A. 269° 10′, Dec. 23° 50′, south. It has an elliptical form, and nearly 30′ length and 5′ width. Through good telescopes, it is resolvable into stars.

### STELLAR NEBULÆ.

Under this name are included the nebulæ which appear to abound with fixed stars.

Fig. 28. A beautiful, round nebula, increasing in

light towards the middle; at the centre of the nebula there is a single fixed star. This nebula stands south of $\beta$ in the Great Bear. R A. 157° 0′, Dec. 54° 24′. The diameter of the whole nebula is about a minute—that of the round, light nucleus, 15″.

Fig. 29. In Gemini. R. A. 109° 45′, Dec. 21° 15′. A round, light nebula of 25″ diameter, with a star of the 8th magnitude near its centre.

Fig. 30. A long, bright, elliptical star nebula, in the Great Lion. R. A. 168° 33′, Dec. 13° 55′. From the border toward the centre, the light increases very slowly at first; but, nearer the centre, it increases very rapidly. In the centre itself, the light is quite starlike. The apparent length of the nebula is 7′, and the width 4′.

Fig. 31. A very small, brilliant star, in a large, irregular, oval atmosphere, in Berenice's Hair. R. A. 190° 30′, Dec. 26° 26′.

Fig. 32. A long, narrow, spindle-shaped nebula, in the Great Lion. R. A. 167° 45′, Dec. 14° 32′. In the middle, where it becomes suddenly bright, it appears to have a star. Length 15′, width 1′.

Fig. 33. A star of the 9th magnitude, with a light nebula attached to it, in the Unicorn. R. A. 97° 30′, Dec. 8° 53′. The comet-like, nebulous tail is about 1′ in length.

Fig. 34. A very long, narrow, spindle-shaped nebulous streak, in Berenice's Hair. R. A. 187°

0′, Dec. 26° 56′. In the middle is a star of the 9th magnitude. Length 15′, width 30″. Near and parallel to it, stands a smaller nebula of nearly the same form.

Fig. 35. A star of the 9th magnitude, with a light, fan-like, nebulous tail, in the Unicorn. R. A. 97° 28′, Dec. 8° 53′. Length and width of the tail, nearly 1′. The end of the tail appears not to touch the star, and the star appears faint and ill-defined.

Fig. 36. A similar fan-shaped nebula in the Great Bear, in the extremity of which is a star of the 9th magnitude. R. A. 131° 45, Dec. 54° 25′. There is also seen a very fine little star, clearly glistening through the nebula.

Fig. 37. A small, faint, elliptical nebula, in the Greyhound. R. A. 192° 45′, Dec. 35° 47′. On each end of the ellipse is a star of the 8th magnitude.

Fig. 38. A long, spindle-shaped nebula in Pegasus. R. A. 344° 6′, Dec. 11° 25′. Length 2′, width 20″. The light regularly increases towards the middle. At each end is a star of the 9th magnitude; but one of these is somewhat out of the axis of the spindle. There are also seen, in the inner part of this nebula, three very fine little stars.

Fig. 39. An elliptical nebula in Hydra, very sharp at each end. On each end is a small star—one of the 8th, the other of the 11th magnitude. R. A. 131° 27′, Dec. 2° 25′, south.

Fig. 40. A bright elliptical nebula in Sagittarius. R. A. 271° 45′, Dec. 19° 56′. In each focus of the ellipse is a small star. The major axis of the ellipse is 50″.

Fig. 41. A round nebula, containing a triple star, in the Wagoner. R. A. 80° 3′, Dec. 34° 7′. The triple star forms an equilateral triangle, whose side is 4″ in length. The three stars are of the 8th, 9th and 10th magnitudes. Some observers pronounce the nebula itself not round, but an equilateral triangle (Fig. 42), so that the position and form of the two triangles, formed by the nebula and by the three stars, bear a striking analogy to each other.

## DOUBLE NEBULÆ.

As we have seen, above, double and multiple stars, so now we give double nebulæ, which, owing to their respective positions, appear, at the first glance, to belong to each other.

Fig. 43. A beautiful double nebula in the Twins. R. A. 108° 45′, Dec. 29° 50′. The two equal, ound nebulæ join one another, and both increase in light toward their centres, which are so bright that they shine almost like stars. A similar one stands in R. A. 225° 0′, Dec. 20° 32′, in Boötes.

Fig. 44. A double nebula in Berenice's Hair. R. A. 187° 0′, Dec. 12° 8′. Both are round, and brighter towards the centres; but one is

considerably greater than the other. Their apparent diameters are 45″ and 60″.

Fig. 45. Two round nebulæ, nearly equal in magnitude, and similar to those in Fig. 43. R. A. 178° 15′, Dec. 17° 55′, south. They join each other, and are much brighter toward their centres.

Fig. 46. An irregular double nebula, near z Ophiuchi. R. A. 266° 0′, Dec. 24° 30′, south. In both these nebulæ, we observe many fine stars.

Fig. 47. Two elliptical nebulæ in the Greyhound, pointed at their extremites. R. A. 188° 55′, Dec. 33° 6′. The two ellipses are perpendicular to each other, and joined at their extremities. The greater is the brighter, and both increase in brightness towards the middle.

HOLLOW NEBULÆ.

Fig. 48. The beautiful annular nebula in Lyra. R. A. 281° 45′, Dec. 32° 49′. The outer diameter of the ring is 6″. The interior opening is not quite so dark as the outer back-ground of the heavens, but appears filled by another fainter nebula. The whole has the appearance of a veil spread over a hoop, or ring. This nebula lies nearly midway between $\beta$ and $\gamma$ Lyræ.

Fig. 49. A very large, elliptical nebula in Perseus, with pointed ends. R. A. 33° 0′, Dec. 41° 34′. Its length is 4′, and breadth 40″. In

the middle we observe an elongated, dark space, and, at the ends of this dark space, two fine little stars. The whole is perhaps a circular nebulous ring, whose plane lies very obliquely to the sun or to the earth, so that it appears only in the form of a narrow ellipse. The form and position of the nebula are similar to those of the opening.

Fig. 50. A three-branched nebula in Sagittarius. R. A. 268° 0′, Dec. 23° 1′, south. The nebula is divided into three branches, and at their point of junction there appears to be a large opening; the branches make angles of near 120° with each other. The diameter of the whole is nearly 7′, and in the middle stand two large stars, one of which is a beautiful double star.

Fig. 51. The great nebula in Charles's Oak. R. A. 159° 0′, Dec. 58° 40′, near the star $\eta$ of the Oak. This nebula, invisible in our country, has the form of a club, and we remark many stars dispersed in it. The nebula with stars seen in the figure over the Club, is a part of the Milky-way, which is very bright in that part of the heavens.

### IRRESOLVABLE AND PLANETARY NEBULÆ.

Most of the nebulæ which have been thus far mentioned. are, with very good telescopes, resolvable, either entirely or in part, into stars; so that they appear to us only as very far distant groups

of stars. The following, even when viewed through the most perfect telescopes, preserve their nebulous appearance.

Fig. 52. The remarkable and great nebula in Andromeda. R. A. 8° 15′, Dec. 40° 20′. It has the form of a very eccentric ellipse with pointed ends, of which the major axis is nearly 30′. Its light increases towards the centre, at first slowly, then rapidly; still, it is not star-like at the centre, but presents a peculiar, strongly condensed, nebulous light. No part of this nebula is resolvable into stars, even with the most powerful telescopes; and it is without any trace of the scales, or flakes, and waves, which are so frequently observed in other nebulæ. Yet we perceive many stars standing behind, and glittering through it. The nebula itself can be discerned, as a small cloud, even by the unassisted eye. It resembles a comet.

Fig. 53. A nebula in the Whale, similar in form to that in Andromeda (Fig. 52.). R. A. 9° 46′ Dec. 26° 13′, south. A very extensive, long, bright, elliptic nebula, which gradually increases in brightness towards the middle.

Fig. 54. An irregular nebulous streak near × Cygni, in the end of the western wing of the Swan. R. A. 309° 39′, Dec. 30° 6′. It forms a very long streak, composed of several distinctly separated parts. Many portions of it are very light. This nebula is milky, without

unevenness of colour, and does not appear to be starry, although we see through it some isolated stars, which do not belong to it. The border of this nebula is in most parts faint.

Under the name of Planetary Nebulæ, are in general classed those round, sharply-defined discs, which in all parts throughout have the same degree of light, not increasing in brightness toward the centre, as in most of the foregoing examples. The surface of the mysterious heavenly bodies of this character, is covered with a fine, scaly, flaky light.

Fig. 55. A planetary nebula in Sagittarius. R. A. 293° 30′, Dec. 14° 33′, south. A round, dimly lighted disc, of 10″ diameter. Its light is in all parts the same, but not starry, though dusky and dispersed. Near it stand two stars of the 11th magnitude, like satellites of the nebula.

Fig. 56. A planetary nebula in the northern hand of Andromeda. R. A. 349° 30′, Dec. 41° 36. A beautiful, though dim, disc of 20″ diameter. Its light is of a pale blueish colour. Near it stands a double star, of the 9th and 10th magnitudes.

Fig. 57. A planetary, elliptical nebula in Orion. R. A. 83° 15′, Dec. 9° 0′. There is a similar one in the Fox, which has a diameter of 2″;

and four small stars surround it, like so many satellites.

Fig. 58. A large planetary nebula in the Great Bear. The disc is generally round, and throughout of the same degree of light. Diameter, 5′. Though not well defined, the light on the border appears suddenly to vanish. R. A. 166° 15′, Dec. 55° 56′. We find a similar one in Boötes of extraordinary magnitude — R. A. 224° 4′, Dec. 19° 6′ — whose diameter is full 6′. The greatest nebula of this kind is in the Swan; R. A. 302° 15′, Dec. 30° 2′. It has a diameter of nearly 15′.

OTHER REMARKABLE NEBULÆ.

Fig. 59. The great and celebrated nebula in the sword-hand of Orion. R. A. 81° 45′, Dec. 5° 30′, south; near the star θ Orionis, nearly four degrees below the middle of the three stars δ, ε and ζ, lying in a right line, which are known by the name of Jacob's Staff. This, from its magnitude and beauty, and from the wonderful variety of its light, is the most remarkable of all the nebulæ. One part of it is uncommonly bright, another cloudy and dim, and a third portion is quite dark, even to blackness. The dark parts are sharply divided from the bright ones. The many stars standing in this nebula shine very brightly, and appear to have a

remarkable covering. The appearance of the whole may be compared to the open mouth of an animal.

Fig. 60. Likewise a very remarkable nebula in the constellation of the Fox. R. A. 298° 0′, Dec. 22° 17′. It is generally elliptical in form, and near the extremities of the transverse axis, has two round spots, which are remarkable for their bright, uniform light; whilst the other parts of the nebula faintly glimmer with a dusky light. The major axis of the ellipse is 8′, and the circular spots are 3′ in diameter. The light of this body is milky, and not resolvable; but four stars of the 9th to the 11th magnitudes are seen in it, which apparently do not belong to the nebula, but only shine through it.

Fig. 61. A very remarkable nebula in the head of the Greyhound, six degrees below the middle star ζ in the tail of the Great Bear. At the centre it has a bright nucleus, which is surrounded at some distance from the border by a wide, light ring. Between this ring and the nucleus, lies a darker concentric ring. The diameter of the whole is $4\frac{1}{2}'$. In one place the outer light ring is divided about one-third of the way round, so that it appears double for that distance. R. A. 287° 37′, Dec. 48° 5′. Near this stands a small round nebula, like a satellite.

Fig. 62. The *Magellanic Clouds*, which are also called the *Cap-clouds* and the *Coal-sacks*, are three dark spots in the bright part of the Milky-way by the Southern Cross. These dark spots, together, occupy a space of several degrees square, and they have their colour chiefly from the entire absence of stars in their neighbourhood. The great Magellanic Spot extends from R. A. 185° 15′, to 196° 15′, and from Dec. 61° to 64°, south, and lies between the Southern Cross and the Bee. The two other small Magellanic Spots are near together, in R. A. 160° 0′, and Dec. 62°, south, between the Cross and Charles's Oak. In Fig. 62, A is the Southern Cross; and B, B and B, are the three Magellanic Spots; and D and D are two groups of stars or bright nebulæ, without the Milky-way.

# PART II.

## SEC. 1.

### GENERAL DESCRIPTION OF THE SOLAR SYSTEM.

When we observe the heavens with attention, we occasionally find bodies which change their positions with regard to each other and to the fixed stars in their vicinity, being seen sometimes on the west, and at others on the east—sometimes above, and at others below—a certain fixed star; whilst the general configuration of the fixed stars composing any constellation in which they may happen to be, remains the same from century to century. These moving bodies are called *planets*, from a Greek word signifying *wanderers*. Their motions, to an observer at the earth, appear, in many instances, exceedingly irregular, sometimes eastward, and at others westward; and at times, also, they appear to be stationary.

Ten bodies of this description have been discovered in the heavens. Five of these have been known in all ages; their names are Mercury, Venus, Mars, Jupiter and Saturn. The other five are hardly visible to the naked eye, and were unknown to the ancients. They have been discovered within the last seventy years, and their names are Vesta, Juno, Ceres, Pallas and Uranus. Besides these ten bodies, which, together

with the Earth, are called *primary planets*, the telescope has revealed to us four smaller bodies revolving around Jupiter, seven around Saturn, and six around Uranus; these, with our own moon, are denominated *secondary planets*. They are also called *moons*, or *satellites*. These thirty bodies, viz., the sun, the eleven primaries, and the eighteen secondaries, compose what is called the *planetary*, or *solar system*.

## SEC. 2.

### THE PTOLEMAIC SYSTEM.

It was a long time before the true magnitudes and real motions of these bodies were ascertained. The ancients generally supposed the earth to be perfectly stationary in the centre of the universe, with the sun, moon and planets revolving about it in several nearly concentric *heavens*, or *spheres*, in the following order: the first, or lowest sphere, was that of the *Moon*, beyond which were those of *Mercury*, *Venus*, the *Sun*, *Mars*, *Jupiter* and *Saturn*—these being all within the sphere of the fixed stars. They found it a very difficult matter to reconcile the annual and daily motions of the sun, which are directly contrary to each other; and still more difficult to account for the particular course which each planet appeared to pursue. It required great ingenuity to invent machinery which would satisfactorily explain all the irregula-

rities observed in the motions of the heavenly bodies. Solid spheres, cycloids, epicycloids, concentric and eccentric circles, and a variety of other celestial machinery, were employed; but without success. They never could account for the motions of Mercury and Venus, and the different apparent magnitudes of the planets at different times, without admitting a motion of the earth.

The foregoing system is called the *Ptolemaic System*, from *Ptolemy*, an Egyptian astronomer, who first gave a full explanation of its details. It was generally received by the Greek philosophers, except Pythagoras and his followers, who maintained the motion of the earth, and are supposed to have derived this knowledge from the ancient Egyptians. The Ptolemaic system held full sway over the minds of men, from the time of its author till near the middle of the sixteenth century.

## SEC. 3.

### THE COPERNICAN SYSTEM.

This system, now known to be the only true one, was first promulgated about the middle of the sixteenth century. Its author, Nicolaus Copernicus, was a native of Thorn, in Prussia. His system at first met with much opposition, but was soon admitted to be the true hypothesis by the learned throughout Europe. In this system, the sun is

considered as placed near the centre; and around this central luminary, the planets revolve in the following order of distances: Mercury, Venus, the Earth, Mars, Vesta, Juno, Ceres, Pallas, Jupiter, Saturn and Uranus.

It is now proved beyond all question that the earth is a planetary body, of a form very nearly spherical, revolving about its axis once every twenty-four hours, and about the sun once every year.

In the earliest ages, the general opinion was that the earth was a vast extended plane; but astronomy had not made much progress before it was observed that the moon was frequently eclipsed by the earth's shadow, and that the form of this shadow, as seen upon the moon's disc, is always circular; from which it necessarily followed that the earth, which casts the shadow, must be spherical, since nothing but a sphere could in all positions cast a circular shadow.

When an eclipse of the moon happens, it is observed earliest by those who live farthest west; which would not be the case if the earth were a plane, since all would then see it at the same instant; nor could the inhabitants of one part of the earth enjoy the light of the sun, while those of another part were deprived of it.

The rotundity of the earth in an easterly and westerly direction, is demonstrated by its having been several times circumnavigated, or sailed around, in that direction. These voyages might

have been performed in one direction, if the earth had been of a cylindrical form; but such cannot be the case; for, when a ship, in any part of the world, departs from the coast in any direction, the persons on board first lose sight of those objects near the level of the sea, then of the more elevated portions of the coast, and lastly of the high towers and mountains. In sailing northward, the stars in the northern part of the heavens will become more elevated; whilst those in the south will gradually approach the horizon, and become invisible. These arguments clearly prove that the general figure of the earth is spherical; but, as will be seen hereafter, it deviates a little from a perfect sphere, being slightly compressed or flattened at the poles.

It has already been shown, in the first part of this work, that the aspect of the heavens at every instant, as referred to the horizon of a spectator upon the surface of the earth, will be the same, whether the earth remains at rest, while all the heavenly bodies revolve about it once in twenty-four hours; or whether the spectator is carried about in the opposite direction, and in the same space of time, by a revolution of the earth. If the former supposition were correct, the nearest fixed star whose distance is now known, would have to move with the inconceivable velocity of more than three thousand millions of miles per second, which is fifteen thousand times the velocity of light, and more than three

thousand millions of times greater than that of a cannon-ball. The improbability, if not the impossibility, of such a rate of motion, is a sufficient argument against the supposition of the rotation of the stars about the earth; and as there is no other alternative, we must admit the diurnal revolution of the earth to be the cause of the apparent diurnal motion of the heavens.

All the planets seem to have a motion sometimes *direct*—that is, from west to east; sometimes *retrograde*—that is, from east to west; and, at other times, they appear for a short period to be *stationary* in the heavens, or to have no motion at all. These appearances cannot be supposed to be the real motions of the planets; and they can only be explained by the hypothesis of Copernicus, that the earth, in common with all the other planets, revolves around the sun: they are the necessary consequences of this system.

## SEC. 4.

### DEFINITIONS.

Planets are opaque bodies, similar to our earth, which move round the sun in certain periods of time. They shine not by their own light, but by the reflection of the light which they receive from the sun. The planets are distinguished into *primary* and *secondary*.

The PRIMARY PLANETS regard the sun as their centre of motion. There are 11 primary planets, distinguished by the following characters and names, viz.: ☿ Mercury, ♀ Venus, ⊕ the Earth, ♂ Mars, ⚵ Vesta, ⚴ Juno, ⚳ Ceres, ⚴ Pallas, ♃ Jupiter, ♄ Saturn, and ♅ Uranus.

The SECONDARY PLANETS, satellites, or moons, regard the primary planets as their centres of motion: thus the moon revolves round the earth, the satellites of Jupiter move round Jupiter, &c. There are 18 secondary planets. The earth has *one* satellite, Jupiter *four*, Saturn *seven*, and Uranus *six*.

The ORBIT of a planet is the imaginary path it describes round the sun. The earth's orbit is in the plane of the ecliptic.

The ZODIAC is an imaginary belt surrounding the heavens, extending 8° on each side of the ecliptic. It is divided into 12 signs of 30° each, which are reckoned from the vernal equinox eastward.

NODES are the two opposite points where the orbit of a planet seems to intersect the ecliptic. That where the planet appears to ascend from the south to the north side of the ecliptic, is called the ascending, or north node, and is marked thus ☊; and the opposite point, where the planet appears to descend from the north to the south, is called the descending, or south node, and is marked ☋.

ASPECT of the stars or planets is their situation with respect to each other. The aspects are: ☌ *Conjunction*, when they are in the same sign and

degree; □ *Quartile*, when they are three signs, or a fourth part of a circle apart; ☍ *Opposition*, when they are six signs, or half a circle, from each other.

The conjunction and opposition (particularly of the moon) are called the *Syzygies;* and the quartile aspect, the *Quadratures.*

Direct. A planet's motion is said to be direct when it appears (to a spectator on the earth) to go forward in the zodiac, according to the order of the signs.

Stationary. A planet is said to be stationary, when (to an observer on the earth) it appears for some time in the same point of the heavens.

Retrograde. A planet is said to retrograde, when it apparently goes backward, or contrary to the order of the signs,

Digit, the twelfth part of the sun or moon's apparent diameter.

Disc, the face of the sun or moon, or of a planet, such as they appear to a spectator on the earth; for, though the sun, moon and planets are really spherical bodies, they appear to be circular planes.

Geocentric latitudes and longitudes of the planets, are their latitudes and longitudes as seen from the earth.

Heliocentric latitudes and longitudes of the planets, are their latitudes and longitudes as they would appear to a spectator situated in the sun.

Apogee, or Apogæum, is that point in the orbit of a planet, the moon, &c., which is farthest from the earth.

Perigee, or Perigæum, is that point in the orbit of a planet, the moon, &c., which is nearest to the earth.

Aphelion, or Aphelium, is that point in the orbit of the earth, or of any other planet, which is farthest from the sun. This point is called the higher Apsis.

Perihelion, or Perihelium, is that point in the orbit of the earth, or of any other planet, which is nearest to the sun. This point is called the lower Apsis.

Line of the Apsides is a straight line joining the higher and lower apsides of a planet, viz.: a line joining the Aphelium and Perihelium.

Eccentricity of the orbit of any planet is the distance between the sun and the centre of the planet's orbit.

Occultation is the obscuration or hiding from our sight any star or planet, by the interposition of the body of the moon, or of some other planet.

Transit is the apparent passage of any planet over the face of the sun, or over the face of another planet. Mercury and Venus, in their transits over the sun's disc, appear like dark specks.

Eclipse of the Sun is a partial or complete occultation of part of the face of the sun, occasioned by an interposition of the moon between the earth and the sun; consequently, all eclipses of the sun happen at the time of new moon.

Eclipse of the Moon is a partial or complete

privation of the light of the moon, occasioned by an interposition of the earth between the sun and the moon; consequently, all eclipses of the moon happen at full moon.

Elongation of a planet is the angle formed by two lines drawn from the earth, the one to the sun, and the other to the planet.

Diurnal Arc is the arc described by the sun, moon, or stars, from their rising to their setting. The sun's semi-diurnal arc is the arc described in half the length of the day.

Nocturnal Arc is the arc described by the sun, moon, or stars, from their setting to their rising.

The Elements of the orbit of a planet are six in number, viz.:

1. The time of passing the perihelion or aphelion, or the mean longitude for a particular date.
2. The mean distance or semi-major axis, or the daily siderial motion.
3. The eccentricity.
4. The longitude of the perihelion or aphelion.
5. The longitude of the ascending node.
6. The inclination of the plane of the orbit to the plane of the ecliptic. If this is considered to be always less than 90°, it must also be stated whether the motion is direct or retrograde.

## SEC. 5.

### KEPLER'S LAWS.

*First Law.*

Kepler ascertained, by direct observation, that the planets all describe *ellipses* round the sun, the latter being situated, not in the centre, but in one of the *foci* of the curve; and it has since been found that several comets move in ellipses: it is highly probable that they all describe paths of the same kind around the sun, although they are so much elongated as not to be distinguishable from the parabola, by observations upon them, during the short time they remain within the reach of our telescopes, which is at most but a few months; while many of them require thousands of years to complete a revolution.

DEFINITION.—The *ellipse* is a curve, of an oval or elongated form, all points of which lie in the same plane. The longest diameter of an ellipse is called the *major*, or *transverse axis;* it divides the curve into two equal parts. The *foci* are two points in the transverse axis, equally distant from the centre; if from any point of the curve two lines be drawn to the two foci, their sum will be equal to the transverse axis. Since the sun is in one of the foci of the elliptical orbit of a planet, the latter will at different times be at unequal distances from the sun. The line joining the cen-

tres of the sun and planet, at any time, is called the *radius vector*.

This law was discovered by Kepler, by his observations of the orbit of Mars, which, fortunately for science, is the most eccentric of all the orbits of the planets then known, except Mercury. This law has been, since Kepler's time, farther generalized; and, instead of an ellipse, it has been found that the orbit of one body round another central body, may be any conic section having the central body in its focus. The two bodies may be either the sun and a planet, or the sun and a comet, or a planet and its satellite.

By a *conic section* is meant the curve formed by the outline of the *section* of a *cone*. If this section is made perpendicularly to the axis of the cone, the curve will be a *circle*. If the plane of the section be slightly inclined to the axis, the curve becomes an ellipse having two foci equidistant from the centre. The distance by which the centre is removed from either focus, is called the *eccentricity*. If the section is made parallel to the surface of the cone, the curve never closes, except on the side where the section commences. In this case, the centre is at an infinite distance, and the curve is called a *parabola*, which is in reality the same as an ellipse with the long axis infinitely great. If the section is still more inclined to the axis, the curve is called a *hyperbola*, with the imaginary centre removed in the contrary direction, so as to be outside of the point where the section commences.

### *Kepler's Second Law.*

Kepler also discovered that the radius vector of a planet describes equal areas in equal times; that is, if radii vectores be drawn from the sun to those points of the orbit occupied by the planet at any equal intervals of time, the areas of the spaces included between any two of these lines which

are adjacent to each other, will be equal—although the planet moves much more rapidly in one part of its orbit than in another, the greatest velocity being when it is nearest the sun, and the least when it is most distant. The velocity decreases as the radius vector increases.

This property of the orbital motion of the planets may be illustrated by a very simple experiment, as follows: Tie a small leaden ball to a fine string, and, having whirled it round with a moderate velocity in a vertical plane, allow the string to coil itself round the finger, held firmly in a horizontal position. The ball will then gradually approach the centre of motion in a spiral line, and the corresponding increase in its angular velocity will show clearly the compensation by which equal areas are described in equal times under a constantly diminishing distance of the body from the centre of motion. If the motion be reversed, and the thread allowed to unwind itself, by giving the ball a sudden impulse, the angular motion will be at first rapid, but will gradually diminish as the distance of the ball from the centre of motion increases.

### *Kepler's Third Law.*

In comparing the distances of the planets from the sun, with their periods of revolution, we find that, the greater the distance, or the larger the orbit, the longer is the time occupied in making a revolution. Kepler discovered that *the squares of the periodic times of any two planets are proportional to the cubes of their mean distances from the sun.* Take, for example, the Earth and Mars, whose periods are 365.2564 and 686.9796 days, and whose distances from the sun are in the pro-

portion of 1 to 1.52369; and it will be found that $(365.2564)^2 : (686.9796)^2 : : (1)^3 : (1.52369)^3$.

The mass of the earth being far smaller than that of the sun, the moon describes a proportionally smaller area round it in a moment of time. So, Uranus, Saturn and Jupiter having greater masses than the earth, their satellites make greater areas round their primaries, in a moment of time, than our moon does round the earth. Still, the third law of Kepler prevails in each secondary system. Among the satellites of the same system, the squares of the periodical times are always as the cubes of their mean distances from the primary of the system.

## SEC. 6.

### THE NEWTONIAN THEORY OF GRAVITATION.

Though Kepler had discovered the three remarkable laws that regulate the motions of secondaries round their primaries, and of primaries round the sun, still the cause of the prevalence of this law was unknown. This discovery was reserved for Sir Isaac Newton, and is justly considered the greatest discovery ever made by an uninspired man.

Newton found that the force which makes an apple fall from a tree to the ground, makes the moon revolve round the earth in an elliptic orbit. This force, which is called *gravity*, or the attraction of *gravitation*, extends its influence, not merely from the earth to the moon, but to the sun, and to the other planets and satellites, and doubt-

less to every star and nebula in the universe. This force of gravity of any two particles of matter diminishes as the square of their distance from each other increases. *Two* particles of matter so close to each other as to form parts of the same solid or fluid, exert upon any third particle not in contact with them, *twice* as much force of attraction as one particle could do. And, generally, the force of attraction in any system of particles, or bodies, increases directly as the number of similar attracting particles, or, in other words, as the *mass* of the system, increases.

There never was a law of such vast importance announced in so few words. The simple principle, that *gravity varies directly as the mass, and inversely as the square of the distance*, enables us to infer *à priori* all of Kepler's laws. If one of several bodies of a system moves round the common centre of gravity of that system by virtue of this law, it will move in a conic section according to the first law; its radius vector will describe equal areas in equal times, according to the second law; and if we take the time of a complete revolution of any one of the bodies of the system as a unit of time, and its mean distance from the sun as the unit of distance, then the time in which any body in the system will complete its orbit, will be equal to the square root of the cube of the mean distance of that body.

Again, if we know the masses of any of the secondary systems, compared with that of the

solar system, we can determine the periods of the satellites at any supposed distance from the centre of gravity of such secondary system. The power of causing areas to be described will be directly as the masses of the two systems, where the distances are the same; and, for different distances, the periods may be ascertained by Kepler's third law, as above.

The Newtonian law of gravity is found to extend to most of the *stellar systems*, and doubtless prevails throughout the universe. If this be admitted, the masses, mean distances, and periods of any one of the stars in a *binary* or *multiple* stellar system are connected together by such a law, that, if any two of them are known, the third follows of course. It was in this way that Bessel, having found the distance of the stellar system 61 Cygni, and knowing its period before, was enabled to determine the mass of this stellar system, which he found to be about two-thirds that of our own. In the appendix will be found Mædler's factor for the masses of the several *stellar systems* whose periods of revolution are known. When the parallax of any of these systems is known, this factor must be divided by it, and afterwards cubed, in order to obtain the mass of the system. The research after the parallax and distance of the fixed stars on Bessel's plan, is still in its infancy. It cannot be doubted that, in the progress of time, perhaps in a single century, the distances and consequent masses of many of the stellar systems

will be ascertained, so as to afford a classification of the fixed stars according to their quantity of matter. If this shall ever be accomplished, and a general average is found to prevail in the masses of stars, as has been shown to be probable, in reference to their brightness and distance asunder, then an estimate may be formed of the quantity of matter in the universe, or rather in that portion of universal space which we are capable of expressing by finite symbols.

## SEC. 7.

### THE SUN,

The glory of our system, and the agent by which the great Creator dispenses light and heat to the surrounding planets, was, in the infancy of astronomy, reckoned among the planets; but it is now numbered among the fixed stars. He appears, indeed, bright and large in comparison with them; but this is only because we are so much nearer to him; for a spectator placed as near to any star as we are to the sun, would see a body as large and bright in that star as the sun appears to us; while the sun, on the contrary, viewed from the same distance as that of the nearest fixed star from us, would assume the appearance of a star, and his attendant planets would be invisible. Although we thus speak of the *nearness* of the sun to the earth, it must be kept in mind that the expression is used

only in a relative sense; for his distance from the earth amounts in round numbers to about 95,000,000 miles; and a cannon-ball, moving at the rate of about eight miles in a minute, would occupy more than twenty-two years in traversing the intervening space. In this respect, therefore, the sun is at a very great distance from the earth; but when it is known that the distance of the nearest fixed star is six hundred thousand times that of the sun, and that a cannon-ball, moving at the rate already supposed, would not pass thence to the earth in less than 1,000,000 years, the sun may well be said to be comparatively *near*.

The figure of the sun is that of a spheroid, higher under the equator than about the poles His diameter is computed at about 890,000 miles, his circumference about 2,700,000 miles, and his bulk upwards of a million of times greater than that of our earth. The sun revolves upon its axis from east to west once in 25 days 14 hours 8 minutes; the axis being inclined to the ecliptic at an angle of $82\frac{1}{2}$ degrees. The north pole of the sun's axis is directed nearly towards $\pi$ Draconis, and its southern pole towards a point midway between $\alpha$ and $\beta$ of the *Ship*. It has also a periodical motion, in nearly a circular direction, round the common centre of all the planetary motions, never deviating from its position by more than twice its diameter.

The sun was long believed to be an immense globe of fire; but some philosophers are of opinion

that, like the earth, it is a cold, opaque, and habitable globe, surrounded with a luminous phosphoric atmosphere, which diffuses light through the whole system. Sir William Herschel supposed that the lucid matter of the sun exists in the manner of luminous clouds, swimming in his transparent atmosphere; and he considered that there are two different regions of solar clouds, and that the lower region consists of clouds less bright than those which compose the upper stratum. The removal or opening of these clouds, he supposed, exhibits the opaque globe of the sun to our view; and hence those dark spots, or *maculæ*, which from time to time are visible upon his disc. The *faculæ*, or bright spots, as he supposed, are caused by a decomposition of the transparent and elastic fluids by which the sun is surrounded; and lucid appearances are thus formed of various degrees of intensity. By observations of these spots, the revolution of the sun upon its axis has been ascertained.

Besides the solar spots, the zodiacal light is a singular phenomenon which accompanies the sun. It begins to be visible, in the fall, a little before sunrise, appearing at first like a faint whitish zone of light, somewhat resembling the galaxy, or milky-way, with its borders ill-defined, and scarcely to be distinguished from the twilight, which is seen commencing near the horizon. It is then but a little elevated, and its figure agrees with that of a lens turned edgewise towards us.

As it rises above the horizon, it becomes brighter and larger, to a certain point; after which, the approach of day renders it gradually less apparent, till it becomes quite invisible. It appears in the west, after sunset, in December and for several months afterwards. It is supposed to be of a lenticular shape, having the sun near its centre, like the nebulous stars occasionally seen in telescopes. It is difficult to comprehend how the particles of matter composing it (if it be material) maintain their position. Perhaps they are in a state of revolution round the sun, like the meteors which the earth encounters in its yearly motion. Professor Olmsted has suggested the idea that the periodical meteors of November 12th, 1833, were a portion of this zodiacal light.

The force of gravity at the surface of the sun is much greater than with us. A body weighing 1 pound at the earth's surface, would weigh 28 pounds $5\frac{3}{4}$ ounces at the sun's; and a heavy body near the sun's surface would fall 456.41 feet in the first second of time. The physical power of our strongest men would hardly enable them to move themselves upon the sun; for a man here, weighing 150 pounds, would there weigh more than 4200 pounds. If the sun's surface is inhabited, it must be by beings very differently organized from those on the earth.

It must be recollected, that if we could carry the same steelyards to the sun, a pound here would weigh a pound there, the counterpoise having in-

creased its gravity as much as the object weighed. A true test would be the elastic force of a spring, or coil.

The sun, in common with the twenty-nine planets and secondaries, has a proper motion in space, estimated by Struve to be half as great as the linear velocity of our earth in its orbit, or about eight miles per second, towards the constellation of Hercules. The point of tendency is in R. A. 259°, Dec. 35°, being about a degree north-east of the small star u Herculis. This point seems to vary its position slowly in the heavens, indicating a change in the tangential direction of our system, or, in other words, a curvilinear or orbital motion round some centre of attraction at present unknown. The proper motions of many of the stars were observed by Halley, Lemonnier, Cassini and Mayer. The latter suggested the true cause of this apparent motion; but Sir Wm. Herschel first pointed out the true quarter of the heavens towards which the motion is now directed. Argelander has tested this point by all the stars known to have a proper motion, and finds a full confirmation. Struve, at Pulkovah, has recently endeavoured to form an estimate of the quantity as well as the direction of this motion. The uranographical effect of it is to enlarge the relative distances of the stars in the constellation of Hercules, and to compress together those which are in its antipode.

Among the ancients, the sun was an object of

idolatry, under various names, as Ham or Cham, Chemosh, Zamos, Osiris, Vulcan, Sol, Phœbus, Apollo, &c.; and was considered as the god of day, the dispenser of light, heat, and fertility, and the good principle with which darkness, or evil, would wage continued warfare till the final consummation, when light, or goodness, should eventually triumph. His symbol, fire, was maintained with the utmost care upon the heathen altars, and even participated in the worship paid to him.

The astronomical sign for the sun ☉ is the periphery of a circle with a central point, indicative of the central situation of the luminary with respect to the solar system.

---

## SEC. 8.

### ☿ MERCURY,

The first planet in the solar system, and the nearest to the sun, performs his revolution about that luminary in 87 days $23\frac{1}{4}$ hours, nearly, which constitutes the length of his year. His rotation upon his axis has been stated at 24 hours $5\frac{1}{2}$ minutes, which would constitute the length of his day; but as no spots by which to determine it have yet been observed upon his face, this is uncertain.

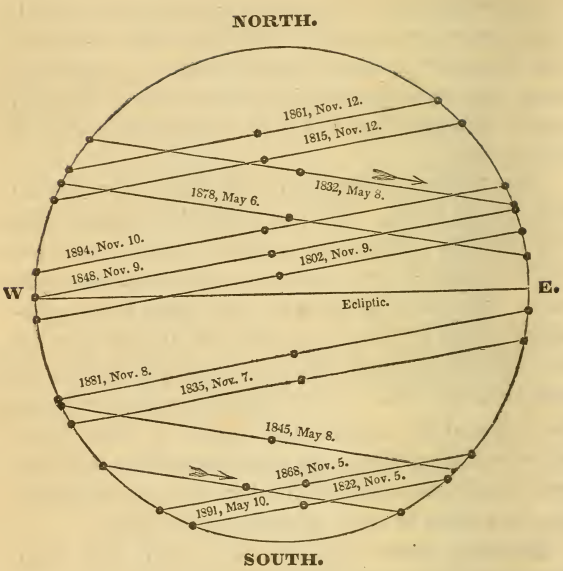
The distance of Mercury from the sun is about 37,000,000 of miles, and he moves in his orbit at

the amazing rate of upwards of 95,000 (or, according to some astronomers, 105,000) miles an hour. His diameter is about 3,000 miles, or somewhat more than one-third of that of the earth. Though small, Mercury has a bright appearance, with a bluish tint.

The orbits of Mercury and Venus are within that of the earth. They are therefore called *inferior* planets. The other planets, whose orbits are without that of the earth, are called *superior* planets. The inferior planets can never be in *opposition;* that is, they can never be in the part of the heavens opposite the sun; but will always be seen near the sun. They sometimes pass between the sun and the earth; this aspect is called their *inferior conjunction.* At other times they will appear in the direction of the sun, but beyond him; they are then in their *superior conjunction.*

Mercury never departs more than 30° from the sun, and can rarely be seen without a telescope. When seen in a telescope, he exhibits the various phases of the moon, or of Venus (see the drawing for Venus), except that he cannot be seen at the full, on account of the interposition of the sun at that time.

The following drawing represents the *transits* of Mercury for the rest of the century:




When the inferior conjunction occurs at the same time that the planet is in one of its nodes, it passes over the sun as the moon does in solar eclipses. This phenomenon is called a *Transit* of Mercury. On account of the small relative diameter, only a small portion of the sun's disc is eclipsed. For a long series of centuries, this transit can only happen in the months of May and November. It was observed for the first time in November, 1631, by Gassendi. The following is a list of all the transits of Mercury from 1631 to

the end of the nineteenth century. *See the drawing.*

| | |
|---|---|
| 1631 Nov. 6. | 1776 Nov. 2. |
| 1644 Nov. 8. | 1782 Nov. 12. |
| 1651 Nov. 2. | 1786 May 3. |
| 1661 May 3. | 1789 Nov. 5. |
| 1664 Nov. 4. | 1799 May 7. |
| 1674 May 6. | 1802 Nov. 8. |
| 1677 Nov. 7. | 1815 Nov. 11. |
| 1690 Nov. 9. | 1822 Nov. 4. |
| 1697 Nov. 2. | 1832 May 5. |
| 1707 May 5. | 1835 Nov. 7. |
| 1710 Nov. 6. | 1845 May 8. |
| 1723 Nov. 9. | 1848 Nov. 9. |
| 1736 Nov. 10. | 1861 Nov. 11. |
| 1740 Nov. 2. | 1868 Nov. 4. |
| 1743 Nov. 4. | 1878 May 6. |
| 1753 May 5. | 1881 Nov. 7. |
| 1756 Nov. 6. | 1891 May 9. |
| 1769 Nov. 9. | 1894 Nov. 10. |

The phases of this planet prove that it does not shine by any inherent light; for in that case it would always appear round.

It is the most dense of all the planets, being $1\frac{1}{2}$ times as dense as the earth. Its mass is about one eight-hundred-thousandth of that of the sun.

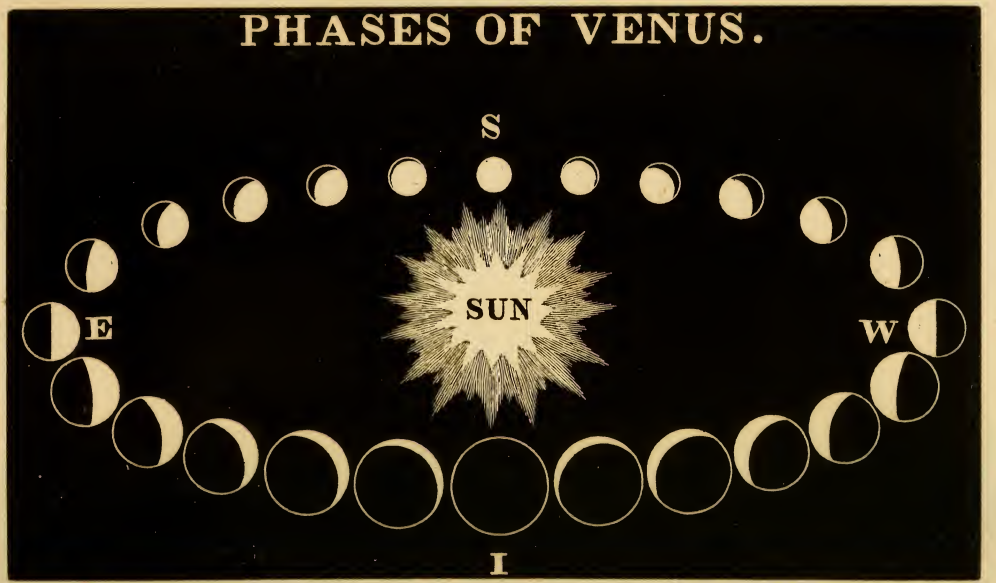
Owing to the great eccentricity of the orbit of Mercury, its year of $86\frac{2}{3}$ solar days is divided into seasons of very unequal length; but since we have no knowledge respecting the direction of its axis, we can have no precise information concerning its seasons. Another consequence of this great eccen-

tricity is, that its days are very unequally lighted: in the perihelion the light from the sun is 11 times, and in the aphelion only 5 times, as intense as with us; and the apparent diameter of the sun is in the former case 1° 39′ 21″.3, in the latter only 1° 8′ 34″.0. The day is, moreover, about 15 minutes longer when the planet is in its perihelion, than when in its aphelion.

Mercury can never experience an eclipse, nor can there ever occur, for it, a transit of another planet over the disc of the sun, unless there be a planet yet undiscovered whose orbit is within that of Mercury. All the other planets will at certain times be in opposition to this one, and the apparent daily motion of these and of the fixed stars is nearly as rapid as for the earth. Venus appears from Mercury about 12 times as brilliant, at a maximum, as from the earth; it may, therefore, in some measure, supply the want of a moon. The earth, as seen from this planet, is large and brilliant, and our moon appears as bright to them as Mars does to us. This last is considerably fainter there than here. For the other planets, there is no very essential difference whether seen from Mercury or the earth; except that, in the former case, all the retrograde motions are confined to a much smaller arc, and to a shorter time. None of the bodies of the system present to it any perceptible phases.

One pound at the earth, has the weight of $9\frac{1}{4}$ ounces at Mercury; the fall of a body in the first second of time is $9\frac{1}{3}$ feet; and the length of a pendulum vibrating seconds is 1.89 feet. These magnitudes are probably nearly the same for all parts of the globe, as no compression has yet been detected, and the rotation, considered as linear, is very slow.

Mercury was considered by the mythologists as the messenger of the gods, and was called Hermes,


PHASES OF VENUS.
S
SUN
E
W
I

Hermes Trismegistos, Thoth, Taut, &c. The astronomical sign of this planet ☿ is supposed by some to represent the caducens with which the heathens furnished Mercury: it consisted of a sceptre entwined by two serpents in the form of two equal semi-circles, and winged at the top.

## SEC. 9.

### ♀ VENUS,

The second planet from the sun, from which she is distant somewhat more than 69,000,000 of miles, moves at the rate of between 75,000 and 80,000 miles per hour, and completes her annual revolution in 224 days 16¾ hours, nearly, and her diurnal rotation in rather less than 24 hours.* Her magnitude is nearly the same as that of the earth; her diameter being about 7630 miles. The circumference of her orbit is at least 433,000,000 of miles.

Venus is easily distinguished by her silver-white appearance, and by surpassing in brightness all the other stars and planets. She is sometimes so brilliant as to be seen in full day by the naked eye. This phenomenon arises from her very dense at-

* Sir Wm. Herschel, after repeated observations, could not satisfy himself as to the rotation of Venus on her axis. Bianchini gives it the incredible term of 24 days 8 hours; but Cassini reduces it to 23 hours 20 minutes, and Schrœter to 23 hours 21 minutes.

mosphere, which is capable of exhibiting reflections. She has phases, like the moon; and the time of her greatest brightness is when she appears in the crescent form. At this season she presents a more pleasing telescopic view than any other of the heavenly bodies. Her surface is diversified with spots; and by the motion of these we ascertain the time she occupies in revolving upon her axis.

Venus appears much larger at one time than at another; and the great variations of her apparent diameter demonstrate her distance from the earth to be extremely variable. *See the drawing.*

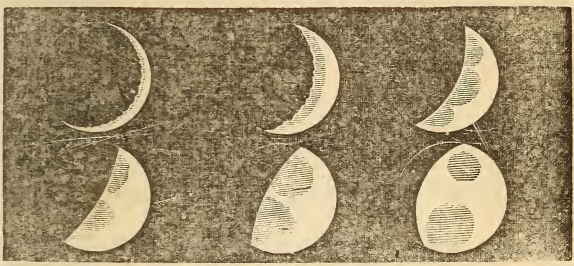
This figure shows Venus at her inferior conjunction at I as a new moon, at her greatest eastern elongation; as evening star at E, as a half-moon of medium size; at her superior conjunction at S, as a small full moon; and at her greatest elongation as morning star at W.

In her seasons, also, she must experience a much greater difference than is known upon our earth; for her axis inclines about 75 degrees to the plane of her orbit, and at her equator she must have two springs, two summers, as many autumns, and two winters, in each year.

This planet is a constant attendant upon the sun, from which she never removes more than 48 degrees, and consequently is never seen at midnight, nor in opposition to that luminary, being visible only for three or four hours in the morning or evening, according as she is before or after the sun. When she rises before the sun, she is seen from the earth to the westward of him, and is

called *the morning star;* but when she sets after him, she is eastward of him, and is then an *evening star*. She is alternately one or the other about 290 days.

The following drawing shows the appearance of Venus when viewed through a very powerful telescope:



Venus, like Mercury, sometimes passes over the sun's disc, but the transits of Venus occur much less frequently than those of Mercury; they have this peculiarity, that the spaces of time between the five transits are 8 years, 122 years, 8 years, and 105 years, and that they can happen only in the months of June and December. The first observation of a transit of Venus was made by Horrox in 1639. The following is a list of all the transits of Venus which have occurred or will occur, from 1639 to the 22d century.

| | |
|---|---|
| 1639 Dec. 4. | 1882 Dec. 6. |
| 1761 June 5. | 2004 June 7. |
| 1769 June 3. | 2012 June 5. |
| 1874 Dec. 8. | |

The transit of June 5th, 1761, was not very successfully observed. That of June 3d, 1769, was observed by astronomers with great care in every part of the globe. Among the most successful, were those of a committee of the American Philosophical Society, at the head of whom was Rittenhouse. The observations of both transits have been reduced with great care by Encke, who makes the mean horizontal equatorial parallax of the sun 8″.578.

This computation of Encke is generally recognised by astronomers as constituting the basis of the solar system. The distances of the other planets are deduced from it by Kepler's third law.

Venus appears, when on the sun, like the drawing for Mercury, except that she is larger in proportion to the size of the sun.

Her year of $230\frac{2}{3}$ solar days is divided, for both hemispheres, into seasons of nearly equal length, since the eccentricity of its orbit is very small. For the same reason, the days are all nearly equal in length; the intensity of the light received from the sun is at all times nearly the same, being $1\frac{9}{10}$ that at the earth; and the apparent diameter of the sun's disc varies only from 44′ 32″.4 to 43′ 56″.1.

Mercury is the only planet which can, for Venus, make a transit over the sun's disc; these phenomena occur much oftener there than at the earth, and this planet appears much larger at Venus than at the earth. The earth is by far the most brilliant star in the evening sky of Venus; its brilliancy at midnight, at the time of its opposition, is 8 times the maximum brightness of Venus as seen from the earth. From no other body of the system, except our moon, does the earth

appear so bright. At Venus our moon outshines Mars, which appears less brilliant there than at the earth. Mercury is for Venus nearly the same as the latter is for the earth, and it presents the same variety of phases. When the earth is in quadrature, about $\frac{5}{6}$ of its disc is illuminated. Observations of the eclipses of our moon, and also of her transits over the earth's disc, are of great importance at Venus.

The daily motion of the stars is only a little less rapid than for the earth. A pound at the earth weighs 14¼ ounces at Venus. Since the magnitudes and masses of these two bodies are nearly equal, the velocity of falling bodies will be nearly the same for both.

Mercury and Venus are called *inferior planets*, because their orbits are within that of the earth: they are the only planets that produce transits over the sun's disc as seen from the earth.

As a goddess, Venus was extensively worshipped by the heathens, under various names, as Ashtaroth, Astarte, Aphrodite, Cotitta, &c. As the morning star, she is known by the titles of Phosphorus and Lucifer; as the evening star, by those of Hesperus and Vesper. Her sign ♀ among astronomers is said to resemble a mirror with a handle at the bottom.

## SEC. 10.

### THE EARTH,

The next planet in order from the sun, is distant from that luminary 95,000,000 of miles. Its equatorial diameter is 7935 miles; its circumfer-

ence upwards of 25,000 miles at the equator; and its superficies nearly 199,000,000 of square miles. The mass of the earth is $\frac{1}{354936}$ of the sun's mass. Its density is 4 times that of the sun, and $5\frac{2}{3}$ times that of water.

The figure of the earth is spherical, except that it is a little flattened at the poles, where the diameter is 36 miles shorter than at the equator. The true shape of the earth was long a contested point among philosophers: some of the ancients, as Leucippus, Anaximander, &c., supposed that it had the figure of a drum; but the most prevailing opinion was, that it consisted of a widely-extended plain, of which the visible horizon formed the boundary, firmly fixed upon some unknown basis, or floating upon an abyss of waters. Of this last opinion were not only some of the ancient poets and philosophers, but also some of the Christian fathers, as Lactantius, St. Augustine, &c. The spherical figure of the earth is now, however, admitted by all true philosophers and astronomers; it is proved by the form of its shadow upon the moon at the time of an eclipse; by the fact of ships sailing round it; and by the tops of distant objects being visible, as they are approached at sea, long before their bottoms can be seen. The flatness of the earth at the poles, and its elevation at the equator, have been ascertained by experiments with a pendulum, and by measurements on the arc of a meridian in different parts of the world.

The revolution of the earth about its axis begets a centri-

fugal force, which acts in opposition to the force of gravity. At the equator, the centrifugal force is $\frac{1}{289}$ of the force of gravity. If the velocity with which the earth revolves about its axis were just seventeen times as great as it actually is, the centrifugal force at the equator would be just equal to the force of gravity, and bodies at that place would have no weight.

The compressed form of the earth, and the centrifugal force, cause bodies in different latitudes to have different weights. A body whose weight at the equator is 1, has at the pole a weight of 1.005176.

A body falls in a vacuum, in the first second of time, at the equator, 16.044 feet; and, at the pole, 16.127 feet.

The length of a seconds pendulum is 3.2510 feet at the equator, and at the pole it is 3.2681 feet. From this it will be seen that a clock, with a seconds pendulum regulated at the equator, if transported to one of the poles would gain 3 minutes 43 seconds daily.

The earth has two sensible and two insensible motions. The *sensible motions* are its annual revolution round the sun, and its diurnal rotation upon its own axis. The *annual revolution*, which forms its year, and by means of the inclination of its poles produces the seasons, is performed in an orbit of nearly 598,000,000 miles, in about $365\frac{1}{4}$ days, moving from west to east at the rate of 68,000 miles an hour, or nearly 20 miles each second. The *diurnal rotation*, which produces alternate day and night, is performed upon its own axis once in 24 hours; or, to speak more accurately, in 23 hours 56 minutes 4 seconds: by which, in addition to the orbital motion just noticed, the people dwelling on the equator are whirled around at the

rate of 1042 miles every hour, and those on the parallel of Philadelphia at the rate of 648 miles per hour!

The *insensible motions* of the earth arise from the precession of the equinoxes, and the decrease in the obliquity of the ecliptic; or, what is the same thing, the decrease of inclination of the earth's axis. The former is $50\frac{224}{1000}$ seconds in a year; the latter has been estimated at $47\frac{6}{10}$ seconds in a century.

### DAY AND NIGHT.

By the rotation of the earth upon its axis once in 24 hours, the alternation of day and night is produced. For, as the earth is spherical, it can present but one of its sides to the sun, and the other side must in the mean time remain in darkness. A ball, with a wire passing through its centre, on which it may turn freely, will afford an easy illustration of this, if held before a candle, or lamp: and any point marked upon the ball may represent any given place of equal latitude upon the globe, which the point would occupy upon the ball, were it divided into northern and southern hemispheres, with their appropriate parallels of latitude.

There are certain places on the earth, where only one day and one night are known in a whole year. These are situated at the poles; and from thence to the polar circles, the days and nights are of some months' continuance, according to their

vicinity to, or distance from, the poles. To understand this, it is necessary to advert to the inclination of the earth's axis, and to keep in mind that the sun is always vertical to some one point, and only one at the same time, upon the terrestrial globe; from this point its rays reach ninety degrees every way, which is the whole extent of a hemisphere. When, therefore, the sun is on the equator, his rays extend to either pole; but when advanced a certain number of degrees to the north of the equator, his rays extend the same number of degrees beyond the north pole, but are withdrawn in an equal proportion from the south pole. When he is vertical to the tropic of Cancer, his greatest distance north of the equator, he of course shines to the same number of degrees on the other side of the north pole—that is, to the arctic circle—while the regions of similar latitude in the south are left in darkness. While he thus shines over the north pole to the arctic circle, no night can be experienced there; and, on the contrary, the regions on the south, within the antarctic circle, are deprived of the benefit of day. Hence it is evident that there can be in a year but one day and one night at the poles, each half a year in length. For, from the moment the sun ascends north of the equator, his rays reach over the north pole, which he continues to illuminate till he returns to the equator; a period of half a year.

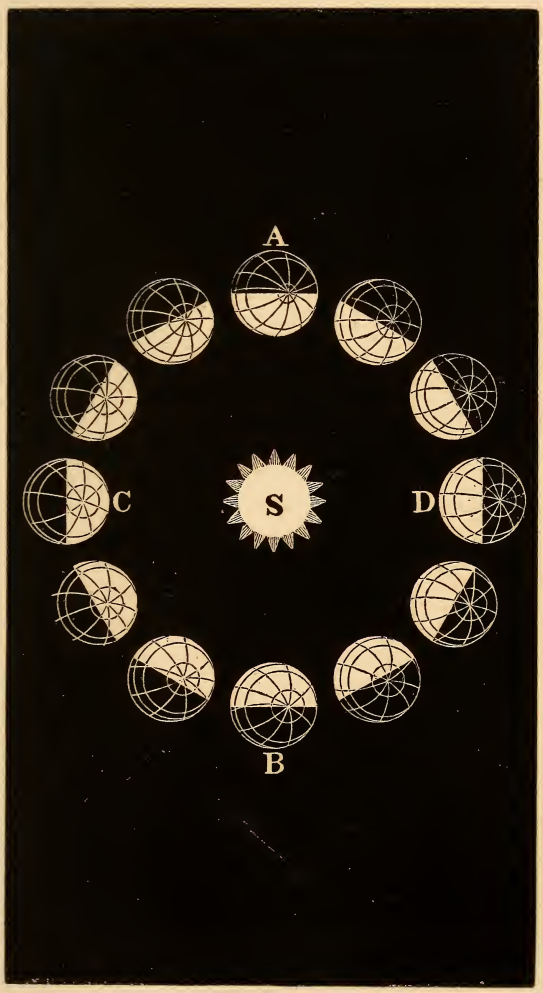
The reverse of this happens with respect to the south pole, while the sun is south of the equator,

till he reaches the tropic of Capricornus. In both cases, the parts between the poles and the polar circles will have their days and nights prolonged, in proportion to the declination of the sun from the equator.

The inhabitants of the polar regions are not, however, in total darkness, even when the sun does not actually rise upon them; for, in the first place, his appearance to them is both anticipated and retarded, by the power of refraction, much longer than to us: and, in the second place, they have a very long twilight, before his rising and after his setting; for the twilight begins when the sun is within eighteen degrees of the horizon, and continues till he has sunk to the same distance below it; and his greatest depression is but $23\frac{1}{2}$ degrees, or $5\frac{1}{2}$ more than will afford them twilight. In addition to this, the moon is above the horizon of the poles for a fortnight together; for, as she passes monthly through the whole ecliptic, which is one half north and the other half south of the equator, she must continue to shine over one or the other of the poles till she returns to the equator. The polar regions have also a third benefit, in having their winter full moons in the highest altitude, describing nearly the same track as their summer sun.

### THE SEASONS.

Upon the position of the earth's axis towards the sun, depends not only the length of days and




The Seasons.

nights, but also the variety of the seasons. By the inclination of the axis of the earth, every part of the planet is by turns presented to the sun: and in those parts where the sun's rays fall most perpendicularly, it is summer; but where they fall in the most oblique direction, it is winter. The intermediate periods, between the greatest and least obliquity of the sun's rays falling on any place, are the seasons of autumn and spring at that place.

In June, the north pole of the earth inclines to the sun, and brings all the northern parts into the light; in these parts, therefore, it is summer. In December, when the earth is in the opposite part of its orbit, the north pole declines from the sun, and the south pole approaches it; and then it is summer to the parts south of the equator, and winter to the north of it. In March and September, the sun is perpendicular to the equator; and then there is equal day and night at all places, except at the poles, which are the boundary of light and darkness. At this season, spring and autumn prevail north and south of the equator; but under that line it is high summer.

These changes are illustrated by the diagram, in which A represents the situation of the earth at the vernal equinox in March, when the spring commences, and the light falls on both poles. C shows the summer solstice in June, when the north pole is turned $23\frac{1}{2}^{\circ}$ towards the sun. B is the autumnal equinox in September, when both

poles are again illuminated. D is the winter solstice in December, when the north pole is again in the dark, and the south pole is inclined $23\frac{1}{2}°$ to the sun. When it is winter in the northern hemisphere, it is summer in the southern; and vice versâ.

### THE EARTH'S SATELLITE.

The earth is attended by a secondary planet, or satellite, the moon, which reflects upon certain portions of its surface, during the night, the light which she receives from the sun; and in like manner the earth reflects the light of the sun upon the moon during her night. The earth, no doubt, presents to the inhabitants of the moon changes nearly similar to those which we witness in that luminary; only the earth must appear to them more than thirteen times as large. When it is *new moon* to our earth, it is *full earth* to the moon, and *vice versâ*.

### THE ATMOSPHERE.

The earth is surrounded with a thin fluid substance, called *the atmosphere*, by means of which the rays of light are reflected, and equally dispersed in all directions. Hence the heavens appear bright in the day-time; for, without this atmosphere, only that portion would be illuminated in which the sun shines; the rest would appear as dark as the night, and the stars would be

seen; neither would there be any twilight, but a sudden transition from sunshine to the blackest darkness at sunset, and from darkness to the blaze of a partial day at sunrise. This atmosphere also constitutes the air we breathe, without which we could not exist; and in it are produced the various phenomena of thunder, lightning, wind, rain, snow, meteors, &c.

This atmosphere is most dense at the surface of the earth, and increases in rarefaction as it rises, till it becomes unfit to support human life. Its precise height is not known, but, by calculation, it is found sufficiently dense at the height of 44 miles to reflect the rays of the sun, and hence to produce twilight. Its weight is immense; for the quantity that presses on a person of moderate size is calculated at 32,400 lbs. avoirdupoise, or nearly 14½ tons; a weight sufficient to crush him to atoms, were it not counterbalanced by the molecular repulsion of the particles of the body, and those of the air which is diffused through most parts of the human frame; so that no inconvenience is sustained.

The mass of the atmosphere is a little less than a millionth part of the earth's mass. If the atmosphere had the same density throughout which it has at the earth's surface, its height would be, in round numbers, 261,000 feet. But, since the density diminishes as the height above the surface of the earth increases, the height of the atmosphere is of course greater than that. It cannot possibly have a height exceeding five times the earth's radius; for at that height the centrifugal force is equal to the force of gravity, and it would

consequently be separated from the upper part of the earth's atmosphere, and scattered through space On that account, we presume that it does not reach that height; but that, by the extreme cold there, it is hindered from any further expansion, and is changed into liquid. For every 300 feet of rise above the surface of the earth, the heat of the atmosphere diminishes 1° of Fahrenheit.

The atmosphere, like other transparent media, refracts the rays of light which pass obliquely through it; and, owing to its variable density, these rays of light describe a curved line, with the concavity toward the earth. For this reason, all the heavenly bodies appear to be higher than they really are, unless when placed exactly at the zenith.

The state of the barometer being 29′ 5″.9 British inches, and the temperature 48°.9 Fahrenheit, the refraction in the horizon amounts to 36′ 7″, and at the altitude of 45° to only 57″.5; in the zenith it is always nothing.

When the atmosphere is thrown into motion, it constitutes *wind*, which is warm, cold, or moist, according to the temperature of the climates where it is generated; producing heat, frost, or rain, as it is more or less imbued with those principles. In the atmosphere, also, the vapours which constantly arise from the earth are condensed, and become clouds; and these, when they exceed in weight that of the atmosphere, fall in showers.

The earth is composed of land and water, the description of which belongs to geography: suffice it here to observe, that the water, besides its currents, is subject to a diurnal motion, called *a tide*, occasioned by the attractive powers of the sun and moon.

The most certain investigations teach us that

the earth's axis is immovable, with reference to the earth itself, and that the equator and the poles always occupy the same position upon its surface. But the position of the axis in space is constantly changing; in a period of 25,600 years, the north pole describes a circle about a certain mean place of the pole of the ecliptic. The following list of north polar stars will serve to give an idea of the nature of this motion.

| | | | | |
|---|---|---|---|---|
| B.C. 4000, | ι Draconis, | 3d magnitude, | 4° | from the pole. |
| " 1700, | α Draconis, | 2d " | very near. | |
| A.D. 2150, | α Ursæ Min., | 2d " | 20′ | from " |
| " 4200, | γ Cephei, | 3d " | 1° 50′ | " " |
| " 6000, | β Cephei, | 3d " | 4° | " " |
| A.D. 7500, | α Cephei, | 3d magnitude, | 2° | from the pole. |
| " 10,200, | α Cygni, | 1st " | 7° | " " |
| " 11,400, | δ Cygni, | 3d | 3° | " " |
| " 13,800, | α Lyræ, | 1st " | 5° | " " |

From this time, a period of 7800 years elapses, during which only stars of the 4th and inferior magnitudes are near the pole; and then, A. D. 21600 the star ι Draconis again occupies the same position with respect to the pole that it did 4000 years B. C.

Our present pole star has held that rank since the time of Hipparchus, and will continue to hold it till the year 3200.

The southern polar stars have been, in former times, among the brightest stars in the Ship Argo. At present there is no star brighter than those of the 5th or 6th magnitude near the south pole.

2000 years hence, the star $\beta$ of the Little Water-Serpent will supply this deficiency. After that time this pole passes through a portion of the heavens in which there are no bright stars. The brilliant star *Canopus* will be within 8° of the south pole when *Vega* or $\alpha$ Lyræ forms our north polar star.

This change in the position of the axis of the heavens is attended with the consequence that many constellations now invisible in the United States will become visible, and vice versâ. For example, the constellations of the Crane, the Indian, the Peacock, the Bird of Paradise, the Southern Triangle, and some others, which are at present invisible in the latitude of Philadelphia, will, 12000 years hence, rise above the horizon of that place. And, on the other hand, the Great Dog, the Hare, the Dove, and the northern part of the Ship Argo, which are now visible here, will then have entirely disappeared from our view.

At that time, also, the equator of the heavens will occupy a place among the stars very different from its present position. The vernal will then be very near where the autumnal equinox is now; and the equator will pass through the Band of the Fishes, the Northern Fish, the Smaller Triangle, the Head of Medusa, Perseus, the Charioteer (very near Capella and $\beta$ in this constellation), the Lynx, the Great Lion, the Virgin, the Hydra, the Wolf, the Scorpion, the Altar, the Southern Crown, the Southern Fish, and the Water-Bearer.

A *second* variation is that which the *disturbing* influence of the planets causes in the position of the *earth's orbit;* the effect of which, after a very long period, will be a slight change in the seasons and in the length of the days. This variation is not sufficient to produce any sensible change in the climate at different periods; and we must look to other than astronomical causes to account for the fact that tropical plants and animals have been found in higher latitudes.

DEFINITION.—The general statement of the law of gravity for the system (see page 198), supposes all the bodies combined to constitute one central body. This is never the case in reality. The separate bodies are continually changing their places with reference to that centre; hence arises a variation of the attraction referred to the centre of the system. This is called the *perturbation,* or *disturbance,* of the motion of the planet or satellite. It is usually very small, compared with the principal force.

A *third* variation is that which takes place in the position of the *perihelion* of the earth's orbit. The earth is nearest the sun 10 days after the winter solstice of the northern hemisphere; 58 years hence this will happen one day later; and after a period of 10,000 years has elapsed, it will be in its perihelion on the longest day of summer. This will exercise some influence upon the duration of the seasons. At the present time, in the northern hemisphere, the winter is 89, the spring is 92½, the summer 93½, and the autumn is 90 days in length; 10,000 years hence the winter will contain 93½, the spring 89, the summer 89, and the autumn 93½ days. The intensity of the summer heat will be only slightly increased, and that of the winter cold will be a very little greater than at present. If the eccentricity of the earth's orbit were as great as that of the orbit of Mars or Mercury,

such a change in the place of the perihelion would produce a far greater variation both in the lengths of the seasons and in the intensity of the heat and cold. The eccentricity is about $\frac{1}{60}$ of the semi-diameter of the earth's orbit, and it is subject to a very slight variation only, so that the inhabitants of the earth would probably never remark these changes, if it were not for the investigations of astronomers.

The earth was deified among the heathen idolaters, under the various titles of Ge, Terra, Tellus, Cybele, Rhea, Vesta, Ceres, Bona Dea, Thea, Titæa, &c., and was called the wife of Cælus, or Uranus, and the mother of the Titans, the Giants, the Cyclops, &c. She was represented as crowned with turrets, holding a sceptre in one hand and a key in the other, with a tame lion lying at her feet.

The astronomical sign of the earth ⊕ represents the terrestrial globe, with the equator. Sometimes it is indicated by a globe, surmounted with a cross, thus ♁.

## SEC. 11.

### GENERAL REMARKS CONCERNING SECONDARIES, MOONS, OR SATELLITES.

The proximity of the Moon to our earth, about which, as a centre, it revolves, enables us perfectly to explain most of the circumstances attending it. But a knowledge of the duration of the seasons, the length of the day, &c., is of little interest to us compared with that of the character

of its surface and other highly important facts relating to its position in the universe. We know the existence of rugged mountains, their forms and heights, and also the absence of a refracting and light-absorbing envelope or atmosphere. This fact being firmly established, enables us to delineate the surface of the moon with precision.

Some general features of this kind may be supposed to be common to all the satellites of our system: others, on the contrary, depend upon some peculiarities, and are, therefore, more or less different for each individual. They have much in common with their primaries: the apparent magnitudes of the sun, planets and comets; their places in the heavens, with reference to the fixed stars and to each other; the intensity of the sun's light, and the length of the year, are very nearly the same for a planet and its satellites; the eclipses are of an opposite character; the conjunctions, oppositions, transits, of the inferior planets—in short, all the phenomena which depend merely upon the position of the body in space—will be of the same character for the whole system of a planet, as for the primary.

It is ascertained with certainty for our moon, the four satellites of Jupiter, and the most distant one of Saturn—and with a high degree of probability for all the other satellites of the solar system—that the times of rotation about their axes are equal to the periods of revolution about their

primaries. Hence it follows that the length of their days will be equal to their synodic periods of revolution; and, consequently, they are, without exception, much longer than the days of the primary planets; an extraordinary advantage possessed by the satellites, in regard to accurate investigations of the heavenly bodies; for the slowness of the apparent motion permits not only a long-continued, but especially a peaceful and undisturbed, observation of them.

Another consequence of the equality of their periods of revolution and rotation is, that their primaries do not partake of the apparent daily motion of the other heavenly bodies; but, for each given place on the surface of a satellite, the planet occupies a constant mean place in the heavens with reference to the horizon and the meridian. It fluctuates about this mean place within certain limits, whose distance depends upon the inequality of the moon's motion, called *libration;* the alternate rising and setting of the whole, or a portion, of the primary planet can occur only to a very small portion of the satellite—to by far the greater part of the latter, the former is either always visible or always invisible.

The primary planet is by far the largest body in the firmament, for all its moons; and appears, as seen from each, many times greater than any of the other satellites. All parts of the planet (with the exception, in some instances, of the polar regions) are visible in succession at its moon;

whilst the inhabitants of the former never see but one side of the moon, and can therefore know nothing directly concerning the other side. This is another great advantage possessed by the satellites over their primaries.

Finally, each primary, as observed from either of its satellites, will present the same variety of phases that our moon does to us. The period of these phases is no other than the lunar day, since both are equal to that of the synodic revolution. To that part of the moon in the meridian of which the primary is situated, one-half of the disc will appear illuminated each evening at sunset, or it will be in its *first quarter;* at each midnight it will be in opposition, and will present its *full* enlightened disc towards the moon; each morning at sunrise it will be in its *last quarter;* and at mid-day it will be in conjunction and entirely invisible, corresponding with our *new moon.* Eclipses of the sun occur for each satellite much oftener, and are larger and of longer duration, than for its primary; and, on the other hand, the eclipses of the latter are, for the satellite, merely the passages of its own very small shadow over the disc of the planet.

These are the essential features common to all the satellites, which lead us to the conclusion that they are far better adapted for observations of the heavens, than are the primary planets. The latter, on the contrary, possess, in some respects, advantages over the former: the determination of

the orbit of a heavenly body, from observations made at one of the *primaries*, presents fewer theoretical difficulties than if the body were observed from a *secondary planet;* for, to the difficulty formerly alluded to, occasioned by the motion of the planet about the sun, is added that of the motion of the satellite about its primary.

The force of *gravity* upon the moons of the solar system is much less than upon the primary planets: the greatest distance through which a body falls during the first second, at any of the former, is about three feet; and at some of the satellites it is less than one foot; whilst at the planets, (the asteroids excepted), the least distance passed through by a falling body during the first second is eight feet.

The ratio of the forces of gravity is the most important element for the motions of all bodies; for it determines the measure of the force required to produce such motions. In the case of the sun, the earth and her moon, this ratio is expressed by the numbers 185, $6\frac{1}{2}$ and 1.

## SEC. 12.

### ☽ THE MOON.

Our moon belongs to the class of secondaries, or satellites. She receives, like the primary planets, her light and heat from the sun. In common with her primary, the earth, she revolves round

the sun in a year. She also revolves around the earth, in an elliptical orbit, at the rate of 2290 miles in an hour, at a mean distance of 238,000 miles. Such is the orbital velocity which the joint masses of the earth and moon, or *tellurian* system, is capable of impressing upon a body at that distance. She completes her revolution round the earth in 29 days 12 hours 44 minutes, nearly. This time of the moon's revolution is called a *synodical* month; but, in consequence of her conjoint motion with the earth around the sun, she appears to revolve from one point in the heavens to the same point again, in about 27 days 7 hours 43 minutes, which constitutes a *siderial* or *periodical* month.

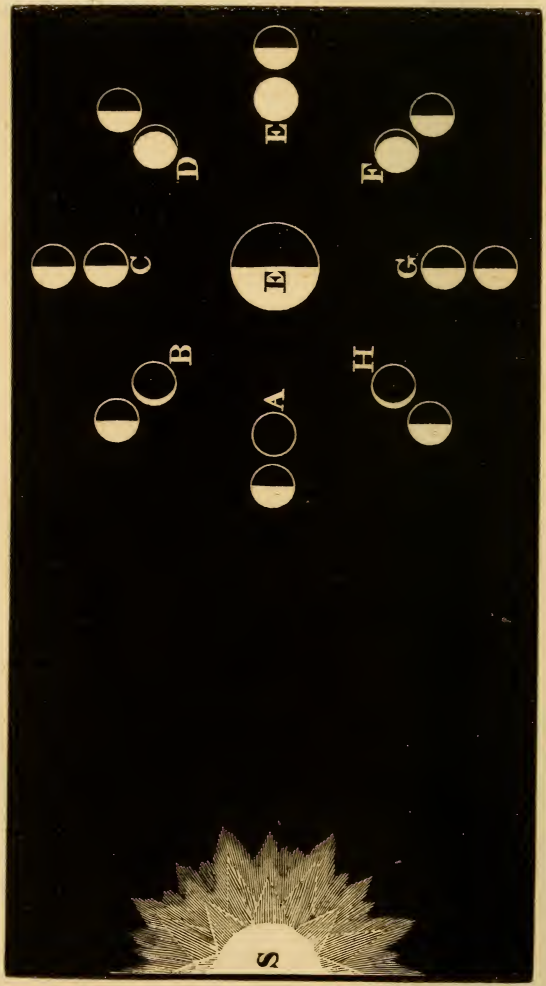
Her diameter is about 2159 miles, and her bulk about a fiftieth part of that of the earth. Her apparent motion is that of rising in the east and setting in the west; but this is owing to the revolution of the earth upon its axis. The moon's real motion round the earth is from west to east. This may be ascertained by remarking, when she is near any particular star, she will approach it from west to east, then be in conjunction with it, and ultimately pass eastward of it.

The moon accompanies the earth in its annual orbit round the sun, and revolves upon her own axis towards the west in the same time that she goes round the earth; so that she always presents the same face to us, with only a slight variation, caused by her librations. Hence, in every revo-

lution, a small portion of her face is carried out of sight on one side, and an equal portion is brought forward on the other. This irregularity, which arises from the moon moving about the earth towards the east, while her rotation upon her axis is towards the west, amounts to about $7\frac{1}{2}$ degrees on each side, and is called her *libration in longitude.* And, in consequence of the moon's axis being inclined to the plane of her orbit, sometimes one of her poles is inclined towards the earth, and sometimes the other; so that we occasionally see more or less of her northern and southern polar regions: this is called her *libration in latitude*, and amounts to about $5\frac{1}{3}$ degrees at each pole.

From the simultaneous motion of the moon upon her axis and in her orbit, it is evident that she can have but one day and one night in one of our lunar months; and as she encompasses the earth not quite thirteen times during his progress round the sun, it is equally manifest that her year is somewhat less than thirteen of her days. And as her axis is almost perpendicular to the plane of the ecliptic, she can have little diversity of seasons, or of length of days.

The earth, as already remarked, reflects the sun's rays upon the moon, in the same manner that the moon reflects them to the earth; but, in consequence of the coincidence of motion between the two bodies, only one half of the moon ever receives the reflection of the earth, and that half is of course never in total darkness; for, when




Phases of the Moon.

turned from the sun, it is illuminated by light reflected from the earth, in the same manner as we are enlightened by a full moon; but the other hemisphere of the moon has a fortnight's light and a fortnight's darkness, alternately. Hence the inhabitants (if any) of one half of the moon never see the earth, unless they travel to gratify their curiosity; for which purpose those on the meridian, opposite to the middle of the enlightened disc, would have to go more than 1700 miles; but their trouble would be more than compensated by the sight of an illumined body thirteen times the size of their own globe, and which would appear to them the largest body in the universe.

The sun and stars rise and set, to the inhabitants of the moon, in the same manner as they do to us.

### PHASES OF THE MOON.

The moon being, like the other planets, a dark or opaque body, enlightened by the sun, can only be illuminated on one of her sides at a time; and hence the different appearances, or phases, which she presents to our view: for, as the light of the moon, visible on the earth, is on that part of her body which is turned towards us, we perceive, according to her various positions with regard to the sun and earth, different degrees of illumination. (*See the drawing.*) Thus she appears at first horned, (in the west, just after sunset,) and

continues to increase in size till she attains a half circle, and ultimately a complete one. She then begins to wane; that part which we first saw is withdrawn from our sight; she presents a half circle on the contrary side to that in which it was before observed; this decreases to a horned streak, and then she disappears.

The disappearance of the moon takes place when she comes to a conjunction with the sun; that is, when she is between that luminary and the earth; because her unenlightened side is then towards us: this is called the *change*, or *new moon*. When she is in opposition to the sun—that is, when she has proceeded through half her orbit—she presents her whole illuminated side to the earth, and is then called a *full moon*: at both these seasons, she is said to be in her *syzygies*. When in her *quadratures*, or a quarter of a circle from the sun, she appears half full, because only one half of her enlightened side is toward the earth; at these times the moon is said to be in her *first* or *last quarter*, according as she is advancing from or towards her change. Before and after her quadrature, she has all the possible variety of phases between a thin circular line and a full face. (*See the drawing of the moon's phases.*)

When the sun and moon are in opposite parts of the heavens—that is, at the time of full moon—the latter rises in the east, as the sun sets in the west. From the change to the full moon, the illuminated part is towards the west, because the sun

is then westward of it; but, from the full moon to the change, the illuminated part is turned to the east, the sun being then eastward of it.

When the moon, at the time of her change, passes in a right line between the sun and the earth, her shadow is projected upon the latter, and obscures the light of the sun, which is called an eclipse of that luminary; and when, at the time of full moon, the earth interposes between the sun and the moon in a right line, the shadow of the earth is projected upon the moon, and a lunar eclipse is the consequence. It is therefore only in conjunctions of the sun and moon that solar eclipses can occur; and lunar eclipses can only happen at the time of their opposition, and then only when the planets are in the same plane, or nearly so. Owing to the inclination of the moon's orbit to that of the earth, eclipses do not take place at every change and full of the moon: there may be as many as seven, but seldom more than six, eclipses in one year; and very frequently not more than two of each luminary.

The inclination of the ecliptic to the equator occasions a peculiar phenomenon of the moon, called the *harvest moon*. This occurs in September, when the moon for several successive evenings rises about the same time, soon after sunset. This is owing to the peculiar ascent of the ecliptic, as may be discovered by turning a celestial globe, when some signs will be seen to ascend rapidly and obliquely, others slowly and almost

perpendicularly: when the full moon is in the former, it deviates from its custom of rising each evening about forty-nine minutes later than on the preceding; and as this variation takes place about the time of harvest, and is of considerable use in lengthening out the day, it is called the *harvest moon.*

The full moon, seen through a telescope of moderately magnifying power, presents a very beautiful sight, diversified with great variety of lustre and colour; but the mountains are best observed at the time of her increase and decrease.

In consequence of the absence of an atmosphere surrounding our moon, the heavens by day must appear there much darker than upon our highest mountains: there, dazzling light and nightly shades immediately succeed each other without the agreeable intervention of a twilight; and the occasional cloudy and obscure days, which upon the earth have an influence so salutary, are entirely unknown at the moon. Perhaps even the brighter stars are there visible in the day time. The hemisphere towards the earth is illuminated by it fourteen times as brilliantly as our night is by the moon: hence, the view of the other heavenly bodies by night must be much more splendid from the other side than from this. For there, nothing interrupts the perfect serenity and darkness of the night. The 350 hours of one of these clear nights, is a number greater than the nights of

a whole year usually afford for observations of the heavenly bodies upon the earth's surface.

The above remarks apply only to $\frac{3}{7}$ of the moon's surface at which the earth is never visible, at the opposite parts of the same dimensions it is always visible, and at the intermediate seventh part the earth is alternately above and below the horizon. The latter portion is a zone of unequal width through the poles of the moon; its width at the poles is 255, at the equator 292, and at the parallels of 40° N. and S. 394 miles wide; and the middle of this zone is the mean border which the moon presents to us.

The sun appears, when seen from the moon, of about the same size as when seen from the earth; its apparent diameter varies from 32′ 39″.5 to 31′ 25″.3. The earth, as seen from the moon, varies in apparent diameter from 1° 47′ 48″.1 to 2° 2′ 58″.8, or nearly 4 times the diameter of the moon as it appears to us.

The difference between the longest and shortest days is much less for the moon than for the earth, owing to the small inclination of the moon's equator to the plane of her orbit. At the pole the length of the day is 179 of our days. The sun there can never be more than $1\frac{1}{2}$° above or below the horizon; and since a person, at the pole of the moon, has but to elevate himself 2000 feet above the surface to be able to see $1\frac{1}{2}$° below the horizon, he may by so doing attain *perpetual sunshine*. There are peaks of mountains far higher than this, in great numbers, in the neighbourhood of both poles. Into many of the valleys and plains in these regions, the sun *never* shines; and the only light they enjoy the benefit of, is that which is reflected by the surrounding mountains, which constitutes for them a kind of twilight, similar to that which is enjoyed by the inhabitants of the deep valleys of Norway.

The lunar year is the same as ours; the difference of seasons is so small as scarcely to be perceptible, for the height of the sun only varies 3° from summer to winter.

As at the earth we have eclipses of the sun and moon, so at the moon there will be eclipses of the sun and earth, from a similar cause; and, for the most part, at the same times, but generally of an opposite kind. The following parallel may be drawn between the eclipses which occur at corresponding times at the earth and at the moon:

| *At the Earth.* | *At the Moon.* |
|---|---|
| A *total* eclipse of the *moon.* | A *total* eclipse of the *sun* for the *whole moon.* |
| A *partial* eclipse of the *moon.* | A *total* eclipse of the *sun* for a part of the moon; and *partial* for the remainder. |
| Passage of the *penumbra* of the earth over the disc of the moon. | A *partial* eclipse of the *sun.* |
| A *total* eclipse of the *sun.* | A *very small* scarcely visible eclipse of the *earth.* |
| An *annular* or *partial* eclipse of the *sun.* | *Nothing.* |

From the above it will be seen that for all our lunar eclipses, whether total or partial, a total eclipse of the sun is experienced by all or a part of the surface of the moon. And, on the other hand, that there is no such thing as an eclipse of the earth of any importance; scarcely a 3000th part of the earth's surface can ever be covered by the moon's shadow at any one time.

Besides the eclipses of the sun, the fixed stars and planets occupying a zone of about 14° width, will frequently be occulted by the earth. The

greatest duration of an occultation there is 4 hours; with us it is only about 70 minutes.

The earth constitutes a timepiece for the moon. The four principal divisions of the day are marked by the phases of the earth; and since it revolves about its axis $29\frac{1}{2}$ times during a lunar day, the positions of remarkable mountains, seas or islands, upon the disc of the earth, might serve to indicate much smaller divisions of time.

### DESCRIPTION OF THE SURFACE OF THE MOON.

The mountains of the moon differ from those on the earth in many respects. Occasionally we see high *insulated mountains*, or peaks, casting a long, well-defined shadow on the surface of the moon, which affords us the means of a perfect measurement of their heights. The surface is more volcanic, and the mountains are higher, and the valleys deeper, in proportion to its size, than on the earth. Some of the mountains are five miles high, and some of the valleys four miles deep.

There are also extensive *mountain ranges* on the surface of the moon, resembling our Alps, Apennines and Andes. Some of these ranges are four miles high; some of them run in a straight line from north-east to south-west, as the range called the Apennines. Others are curved.

*Circular ranges* of mountains form a peculiar feature of the moon's surface, which has no counterpart on that of the other planets. These circular ridges of mountains resemble a prodigious

rampart, or wall, surrounding an extensive plain, or valley, sometimes forty or fifty miles in circumference. These plains are sometimes on a level with the moon's surface, and are called *walled plains;* sometimes depressed a mile or two below that level. Sometimes several circular valleys are formed within one of these large enclosures, or principal valleys.

The name of Newton has been given by Mædler to a *lunar cavern,* or depression, surrounded by a circular range of mountains. This is the deepest cavern in the moon. It has several central and parallel chains of mountains, and one peak, rising a little above the moon's surface, whose height above the bottom of the cavern is four and a half miles; being the highest mountain, from its base, on the whole surface. It is supposed that there is no single mountain, on the earth, high enough, above its immediate base, to fill this enormous cavity. The name of the great philosopher who penetrated deepest into the hidden laws of nature, has been very appropriately given to this cavern, or pit, which is the deepest depression known in the earth or moon.

There are also numerous *crater-formed* elevations, resembling in shape the cup of an acorn These appearances are very similar to the volcanoes on the earth, except that the bottom of the crater is often below the surface of the moon. Around many of these extinct volcanoes, there is

an appearance of portions of lava thrown out at different times, in strata overlapping each other.

There is good reason for believing that the volcanic force of the moon has been for ages extinct. Sir William Herschel's authority has often been quoted in proof of the existence of active volcanoes. The appearances which he noticed still present themselves almost every lunation; but they are attributed by astronomers, to *optical* rather than *physical* causes. The remarks of Herschel are considered rather as descriptive of the appearances, than as an affirmation of the existence of active volcanoes.

Some have supposed that the cause of the present inactivity of the lunar volcanoes, is to be found in the smallness of the moon's size, and the want of an atmosphere, in consequence of which the process of radiation has reduced the temperature of its crust too low for this force to prevail.

The *central mountains* are situated in the middle of the circular plains. They are usually found precisely in the centre; they rise to the height of one or two miles, and cast a well-marked shadow on the plains below. Sometimes these central mountains terminate in several small distinct peaks.

The *crater-formed* elevations reflect more light than any other portion of the moon, and hence the ranges of these elevations form at the time of full moon a number of streaks or radiations. These appear to meet in a large bright spot, surrounded

by a faint shade called Tycho. Maps of the moon's surface have been made which contain the names of several conspicuous objects on the moon's surface, to which the appellation of *seas, lakes, gulfs,* &c., has been given, rather from a fancied resemblance to such objects, than as indicative of their real existence. The names of distinguished philosophers and astronomers have also been assigned to many of these objects.

The heights of some of the principal mountains, according to the recent measures of Mædler, are as follow:

| | | |
|---|---|---|
| Posidonius . . | 19,830 feet. | 3.76 miles. |
| Tycho . . . | 20,190 " | 3.83 " |
| Calippus . . . | 20,390 " | 3.86 " |
| Casatus . . . | 22,810 " | 4.32 " |
| Newton . . . | 23,830 " | 4.52 " |
| Clavius . . . | 19,030 " | 3.60 " |
| Huygens . . . | 18,670 " | 3.54 " |
| Blancanus . . | 18,010 " | 3.41 " |
| Clavius . . . | 18,320 " | 3.47 " |
| Moretus . . . | 18,440 " | 3.49 " |

The worship of the moon formed an important part of the ancient heathen rites; and she was personified under a vast variety of names; as Isis, Astarte, Selene, Luna, Diana, Proserpina, Hecate, Cynthia, Phœbe, and numerous others. The astronomical sign of the moon is a crescent, ☽, or the moon in her first quarter.

## SEC. 13.

### ♂ MARS,

Whose orbit is next beyond that of the earth, is the first of the superior planets, and is known in the heavens by its red, dusky appearance: the latter proceeds either from a very dense atmosphere, or from the matter of the planet being best adapted for reflecting red rays of light.

The distance of Mars from the sun is somewhat more than 145,000,000 of miles, or half as far again as that of our earth; and, moving at the rate of about 55,000 miles every hour, he performs his annual circuit, from west to east, in about 687 of our days. The diameter of Mars is only about 4135 miles, or a little more than half that of the earth. His form is spheroidal, his polar and equatorial diameters being as 15 to 16. When in opposition to the sun, he appears about five times as large as at the time of conjunction; because, in the former case he is much nearer the earth than in the latter. It has been supposed that, on account of his distance from the sun, Mars cannot enjoy more than half the light and heat that the earth receives.

Viewed through a telescope, Mars generally appears full; yet at times he is observed to increase and decrease like the moon, but is never horned. The plane of his orbit is inclined to the ecliptic 1° 51′ 4″; and his axis is inclined to the former 61° 18′.

He has no satellite. His greatest apparent diameter is 23″, his least 3″.3. The mean value is 5″.8. His volume is 0.140, and his density 0.948, compared with those of the earth. His mass is $\frac{1}{2,680,337}$ that of the sun. A pound here would weigh half a pound at Mars. All other circumstances being the same, the amount of light and heat at the planet Mars are 0.43 as great as at the earth.

Mars is distinguished from the other planets by its reddish light. Spots have been observed which do not change their places on the body of the planet. The cause of these spots cannot therefore be found in an atmosphere surrounding the planet, but must be sought for in the difference of the reflection of the sun's light by differently constituted portions of the surface of the planet, in the same manner as upon the earth the green plains, the mountains covered with woods, the sandy deserts, the snowy fields, &c., all reflect the sun's light differently.

The spots upon the surface of Mars sometimes change their colour a little, from which we may infer the existence of an atmosphere. The most remarkable of these spots is at the south pole. It is large, bright, white, circular and well defined, the south pole of the planet being at its centre. The magnitude of this spot is changeable, being smallest when it is summer, and largest when it is winter, in the southern hemisphere of the planet. For which reason this spot has been called the snowy zone of Mars. (*See the drawing.*)

The observations of these spots have indicated a period of revolution around its axis in 24h. 37m. 20s., and an inclination of its axis to the ecliptic of 63° 9′.

In its geocentric course, Mars, as well as all the other superior planets, can attain every possible elongation from the sun. Since its distance from the sun, as is the case with all the other superior planets, is greater than the distance of the earth from the sun, there will be no inferior conjunction for this planet. During the opposition, its retrograde geocentric motion is at its maximum.

Mars moves in the retrograde direction through an arc which varies from 11° 8′ to 19° 30′, in a time varying from 62 days to 81 days. The elongation from the sun at which this retrogradation begins and terminates, varies from 129° 2′ to 145° 37′.

The annual period of this planet, occupying 668⅔ martial days, is divided into four seasons, as follows:

| Northern Hemisphere. | Southern Hemisphere. | |
|---|---|---|
| Spring | Autumn . . . | 191⅓ days. |
| Summer | Winter . . . | 181 " |
| Autumn | Spring . . . | 149⅓ " |
| Winter | Summer . . . | 147 " |

This very great inequality in the length of the seasons, is occasioned by the eccentricity of the orbit of Mars, which is more than 8 times as great as that of the earth's orbit, or about $\frac{1}{2\frac{1}{1}}$ of the diameter. The intensity of the solar light and heat in the northern summer is to that in the southern as 20 is to 29. Hence, it follows, that for the northern hemisphere the summer is longer with less intense heat, and the winter shorter and more mild than for the southern hemisphere. The surface of Mars may be divided into zones in

the same manner as the earth's, the *torrid zone* extending 28° 42′ on each side of the equator; the *temperate* zones, from 28° 42′ to 61° 18′ of latitude; and the *frigid* zones, from the parallels of 61° 18′ to the poles. The torrid zone, or that portion over which the sun will sometimes be in the zenith, occupies nearly half the surface of the planet. The inequality of the days as well as of the seasons, is much greater for Mars than for the earth. The average, or mean length of the day, is 12h. 19m. 47s.

| | Longest Day. | Shortest Day. |
|---|---|---|
| In latitude 40° ..... | 16h. 14m. ..... | 8h. 25½m. |
| " 50 ..... | 17 54 ..... | 6 45½ |
| " 60 ..... | 22 10½ ..... | 2 29 |

In latitude 42½°, the longest day is double; in 52°, it is three times, and in 57½°, it is 5 times the shortest day. This inequality is occasioned chiefly by the inclination of the equator to the orbit, but the eccentricity of the latter is another source of variation in the length of the day.

The orbits of Mercury, Venus, the Earth, and the Moon, being within that of Mars, there will occasionally be transits of these bodies over the sun's disc, as seen from Mars. The superior planets adorn the heavens for Mars nearly in the same manner as they do for us, but it is less favourably situated with reference to the inferior planets. The earth is to it what Venus is to us, though only about half as bright; yet it is generally the brightest star in its firmament. Both Mercury and Venus, when seen from Mars, must be very near the sun.

If we consider the intensity of the sun's light at the earth equal to 100, it will be at Mars equal to 52 in the perihelion and 37 in the aphelion. The apparent diameter of the sun, as seen from Mars, varies from 23′ 9″.4 to 19′ 12″.6; or, in other words, it appears at that planet about two-thirds as large as it does to us.

The apparent motion of the fixed stars is a little slower there than at the earth. The north pole is directed towards

a point in the Great Bear, which may be found by drawing a line from $\eta$ of that constellation to $\alpha$ of the Dragon, and to this line drawing a perpendicular from $\zeta$ of the Great Bear; the point where these lines intersect, is the north pole of the heavens for Mars; the south pole is very near $\alpha$ of Eridanus or *Achernar*, a star of the first magnitude.

Mars, among the mythologists, was considered as the god of war and of hunting: he bore the names of Ares, Arius, Arioch, Mamers, Camulus, Woden, Gradivus, Mavors, Quirinus, Enyalus, Salisubsalus, &c. The original Mars, to whom is ascribed the invention of arms, and the art of ranging troops in order of battle, is by many supposed to have been Nimrod, the Belus of the Babylonians, who is mentioned in scripture as "a mighty hunter before the Lord:" but this is very doubtful. Mars was the reputed son of Juno, and is generally represented on antique monuments and medals as a robust man, armed with a helmet, pike, and shield. Sometimes he is mounted on a war-chariot, which is guided by Bellona, the goddess of war, and drawn by two horses, named Terror and Fear. Among astronomers, Mars is characterised by a spear and shield, ♂.

## SEC. 14.

### ⚴ VESTA.

Vesta was discovered by Dr. Olbers, a physician of Bremen, in the kingdom of Hanover, on the 29th March, 1807. It is so very small as to

be invisible to the naked eye: through a telescope it appears as a star of the 6th magnitude, and of a dusky colour. The diameter of Vesta is estimated at only 238 miles, or, according to some, 270 miles; her distance from the sun is nearly 225,000,000 of miles, or $2\frac{1}{2}$ times that of the earth; and she performs her annual revolution in 1325 days. The inclination of her orbit to the plane of the ecliptic is 7° 8′. Although the mean distance of this planet from the sun is less by some millions of miles than that of Juno, or Pallas, she is sometimes at a much greater distance than either of them, on account of the eccentricity of their orbits.

According to the heathen mythology, Vesta was the sister and wife of Saturn; and her daughter, called Vesta the Younger, the reputed goddess of Chastity, was represented by no image, but a perpetual fire was maintained on her altar, which was carefully attended by virgin priestesses, called *Vestals*. Hence modern astronomers have adopted the figure of an altar with a fire blazing upon it, as her emblem, ⚶.

## SEC. 15.

### ⚵ JUNO.

Juno was discovered by M. Harding, of Lilienthal, near Bremen, on the 1st September, 1804. It revolves round the sun in rather less than 1591

days, at the mean distance of 254,000,000 of miles. At its aphelion point it is five-thirds the distance from the sun that it is at the perihelion; and its orbit crosses those of the other three asteroids, though not in the same plane. The diameter of this planet is stated at 460 miles; its orbit has an inclination to the ecliptic of somewhat more than 13°. It is invisible to the naked eye, but through a telescope it has a resemblance to a star of the eighth magnitude.

Juno, among the mythologists, was the sister and wife of Jupiter, and queen of heaven; and she had names as numerous as any of the heathen deities. The peacock was sacred to her; and Iris (the rainbow) was her constant attendant. Although *now* translated into a planet, she seems to have been originally the *Ionah* (messenger) or dove of Noah, who brought to that patriarch the olive-leaf, emblematical of the restoration of the divine favour towards the human race. Her astronomical emblem is by some a sceptre surmounted with a star, token of magnificence, ⚹; by others, a mirror, crowned with a star ♁, the emblems of beauty and power.

## SEC. 16.

### ♀ CERES.

Ceres was discovered by M. Piazzi, of Palermo, in Sicily, on the 1st January, 1801. Her mean

distance from the sun is nearly 263,000,000 of miles, and she performs her annual revolution in 1681 days. There is very little difference between the aphelion and perihelion points of this planet; but its orbit, which inclines to the ecliptic rather more than $10\frac{1}{2}°$, is crossed by the orbits of Juno and Pallas. The diameter of this planet is 460 miles: it is much too small, at such a distance, to be discovered by the naked eye; and through a telescope it appears like a star of the eighth magnitude, resembling Mars in colour.

Ceres, in idolatrous times, was the reputed goddess of Corn and Harvests, the daughter of Saturn and Vesta, and mother to Proserpine. She was held in great veneration; and, among a variety of other titles, had that of *Bona Dea*, the beneficent goddess. Her emblem, among astronomers, is a sickle, ⚳, the instrument of the harvest.

## SEC. 17.

### ⚴ PALLAS.

Pallas was discovered by Dr. Olbers, of Bremen, on the 28th March, 1802. It moves between Mars and Ceres at the distance of nearly 263,000,000 of miles from the sun; completing its annual revolution in rather less than 1682 days. The diameter of this planet is 670 miles. The aphelion point of this planet is about once and a

half as distant from the sun as its perihelion: its orbit crosses the orbits of the other three asteroids; and its inclination to the plane of the ecliptic is prodigiously great, being about $34\frac{1}{2}°$, which is far beyond the limits of the zodiacal belt.

Among the mythologists, Pallas, the same with Minerva, was the daughter of Jupiter, from whose brain she was fabled to have sprung completely armed, and brandishing a spear. She was the reputed goddess of Wisdom; and the owl and the cock were her favourite birds. The olive-tree was also sacred to her. She was likewise the patroness of the Liberal Arts. Her astronomical emblem is the head of a spear, ♀.

## SEC. 18.

### GENERAL REMARKS CONCERNING THE ASTEROIDS.

Dr. Olbers had conceived the idea that Ceres might possibly be the fragment of a larger planet which formerly revolved between the orbits of Mars and Jupiter, and had been burst asunder by some unknown powerful force, and that other bodies similar to these three were yet to be found. This idea, whether correct or not, appears to have led to the discovery of the other three asteroids. Thus, four primary planets belonging to our system, were discovered in a little more than six years.

It is quite remarkable, that the possibility of the existence of a planet between Mars and Jupiter had been previously conjectured, by Professor Bode, of Berlin, on the ground that the successive intervals between the orbits of the planets vary pretty nearly according to a certain law; while the interval between Mars and Jupiter forms the only exception, being much too great, and requiring a planet of the mean distance of the asteroids to make the series complete. If a planet having this mean distance should have exploded by any internal force, the fragments must, on making a period, return near the same portion of space in the solar system. It was by searching in this portion of space that the three last asteroids were discovered. So carefully were the heavens watched for the first twenty years of the century by the German astronomers, that Dr. Olbers states with confidence that no asteroid of the eighth magnitude could have traversed that region without being discovered.

We have but a very imperfect knowledge of the magnitudes of these planets, and none respecting their rotations and the positions of their axes. Lamont has determined the probable diameter of Pallas to be about 670 miles. This is the largest of the four, and Vesta is the smallest; its surface being estimated at 229,000 square miles, or about one-tenth of the surface of the United States.

Our information concerning these small bodies is confined to the elements of their orbits, and other circumstances de-

pending on these elements. The orbits of Pallas and Juno are very eccentric; and, consequently, the intensity of light and heat, and the apparent magnitude of the sun, are very different for them in different parts of their course. The following table will show the maxima and minima values of these quantities, the average intensity of the light received at the earth being called 100.

| | Intensity of Light in the | | Apparent Diameter of the Sun in the | |
|---|---|---|---|---|
| | Perihelion. | Aphelion. | Perihelion. | Aphelion. |
| Vesta | 22 | 15 | 14′ 53″.8 | 12′ 26″.2 |
| Juno | 26 | 9 | 16 9 .8 | 9 32 .1 |
| Ceres | 16 | 11 | 12 32 .5 | 10 43 .4 |
| Pallas | 23 | 8 | 15 12 .6 | 9 17 .6 |

Another peculiarity of the orbits of these planets is, their great inclination to the orbit of the earth, or ecliptic. The orbit of Vesta is inclined 7° 8′; that of Juno, 13° 4′; that of Ceres, 10° 37′; and that of Pallas, 34° 35′: so that they will sometimes be found beyond the limits of the zodiac, and have for that reason been called the *ultra-zodiacal* planets.

These planets revolve around the sun at nearly the same mean distances, in round numbers, as follows:

Vesta ..... 225 millions of miles.
Juno ..... 254 " "
Ceres ..... 263 " "
Pallas ..... 263 " "

Their terms of revolution are — Vesta, 1325 days; Juno, 1591 days; Ceres, 1681 days; and Pallas, 1682 days. This is a very different arrangement from that of the other planets, whose mean distances and times of revolution are immensely different; whilst two of these, Ceres and Pallas, have nearly the same mean distance, and their periods differ hardly a single day. These two planets, thus revolving around the sun almost at the same mean distance, and in the same time, present a singular anomaly in the solar system; they do not, however, move in the same, or nearly the same, path—their elliptic orbits being of very different forms; that of Pallas

much more elongated than that of Ceres, and the two paths lying in planes very differently inclined.

The brightest star visible in their heavens is Jupiter, at his opposition; when this occurs at the time of the aphelion of Pallas, he will appear at that planet $2\frac{1}{3}$ times larger than he ever does to us, and will be within 170 millions of miles of Pallas, who will then receive from him six times as much light as we ever do. The other three planets can never be nearer to Jupiter than from 220 to 340 millions of miles.

For observations of the inferior planets, Mercury, Venus, the Earth, and Mars, these planets are as unfavourably situated as the earth is for observations of Mercury. The transits of these inferior planets over the sun's disc will occur very seldom, on account of the small apparent diameter of the latter, and the great inclination of the orbits of the small planets. For Juno and Pallas there will hardly be one in a century of our years. Saturn and Uranus, in opposition, appear somewhat larger there than at the earth.

The force of gravity at the surfaces of these bodies must be very small. If we suppose them to be of the same density as Mercury, which is the most dense, so far as is known, of all the planets, then, supposing the diameters to be as in the following table, we shall have:

| | Diameters. | Fall in the first Second. | Length of the Seconds Pendulum. |
|---|---|---|---|
| Vesta | 270 miles | 7 inches | 1 inch |
| Juno | 460 " | 11 " | 2 " |
| Ceres | 460 " | 11 " | 2 " |
| Pallas | 670 " | 16 " | 3 " |

The weight of a pound at the earth would there be only about an ounce; and the physical power of an inhabitant of the earth would enable him to accomplish wonders upon one of these planets.

## SEC. 19.

### ♃ JUPITER.

Jupiter, the largest orb in our system, with the exception of the sun, is about 91,000 miles in diameter, and occupies 11 years 315 days 14½ hours, nearly, in performing his circuit about the sun, from which he is distant upwards of 494,000,000 miles, travelling at the rate of 28,000 miles in an hour.

This planet is full five times as far from the sun as the earth is. Its revolution on its axis is accomplished in 9 hours 55 minutes 26½ seconds —a rotary velocity twenty-five times that of the earth. Hence its year consists of 10,477 Jovian days. In consequence of this swift diurnal rotation, the equatorial diameter of Jupiter is 6000 miles greater than his polar diameter.

The density of Jupiter is not quite one-fourth of that of the earth, and a little greater than that of water. Hence, although Jupiter is 1300 times as large as the earth in bulk, its mass of matter, or weight, is only about 300 times as great.

The attracting mass of Jupiter being 300 times the earth's, and his semi-diameter being eleven times as great as ours, gravity at his surface will be only 2½ times that of ours. In other words, a pound here would weigh 2½ pounds there.

There is, however, a great difference in the weight of bodies on different parts of the surface of this planet, in consequence of its being very much flattened or compressed at the poles. This compression amounts to nearly $\frac{1}{15}$ of its diameter, its polar being only $\frac{14}{15}$ of its equatorial diameter. This difference is perceptible with the aid of a good telescope, the disc appearing not perfectly round, but slightly oval, or a little elongated in the direction of the satellites, which are always seen in the direction of its equator. (*See the Frontispiece.*) Hence a body at the pole, being much nearer the centre of Jupiter, will weigh much more than the same body would at the equator.

There is, moreover, another cause of difference between the force of gravity at the equator and that at the poles. This is, the rapid revolution of the planet about its axis. The equatorial regions move in the circumference of a circle at the surprising velocity of nearly 28,000 miles an hour—the effect of which is to produce a very great *centrifugal* force, or tendency to fly off from the centre, in bodies near the equator. This counteracts, in part, the gravity of those bodies; whilst, at the poles, the weight of bodies is not at all diminished by this cause. The combined effect of these two causes is, that a body will weigh three-tenths more at the pole of Jupiter, than at its equator. There must, of course, be a corresponding variation in the length of the pendulum on different parts of the surface of this planet. In fact, a pendulum vibrating seconds, at the equator, would be 34.9 feet, and at the poles 45.2 feet, in length; or nearly one-third longer than that at the equator.

The *inclination* of the equator of Jupiter to his orbit is only 3° 5′; and the *eccentricity* of the latter being very small, the difference of the seasons will be but slight; and that of the lengths of days at different seasons of the year will also be very small, compared with the earth; for the variation in the meridian height of the sun, at any given place, throughout the year, cannot exceed 6° 10′.

| | Longest Day. | Shortest Day. |
|---|---|---|
| In latitude 40° ..... | 5h. 6m. 26s. .... | 4h. 49m. 14s. |
| " 60 ..... | 5 15 47 .... | 4 39 53 |

It is only within 3° 5′ of the poles that the sun can remain invisible during any entire revolution of the planet about its axis.

The intensity of the light and heat of the sun at Jupiter is $\frac{1}{27}$ of that at the earth, and the sun appears there under an angle of 6′ 10″; or his apparent diameter, when seen from Jupiter, is about one-fifth as great as when seen from the earth.

The ecliptic and equator of Jupiter lie nearly in the same plane as our ecliptic. In consequence of the rapid motion of this planet, the sun and stars will appear to move from the eastern to the western horizon in a little more than five hours, or $2\frac{1}{2}$ times faster than in our firmament; so that the apparent motion of all these bodies, except the stars near the poles, will be rendered perceptible to the eye, by a contemplation of them, for only a few moments. This constitutes one of the most interesting peculiarities in the firmament of Jupiter.

The view of Saturn from Jupiter will be better than from any other planet. Saturn will appear 40″, and his ring 90″, in diameter; or one-twentieth as large as we see the sun, and one-fourth as large as it appears from Jupiter. The transits of the inferior planets over the sun's disc will be more frequent, but more difficult to observe at Jupiter than at our earth.

Jupiter exceeds all the other planets in brightness (except sometimes Venus), and may thus be easily distinguished. When viewed through a telescope, his disc is perceived to be surrounded by faint cloudy stripes, called *zones*, or *belts*, which, though generally parallel to his equator, are subject to great variations both in figure and number. Sometimes eight have been seen at once, sometimes only one: sometimes they continue for

three months with little or no variation, and sometimes a new belt has been formed in less than two hours. From their being subject to such changes, Dr. Brewster suggests that the atmosphere of Jupiter reflects more light than the body of the planet; and that the clouds which compose it, being thrown into parallel strata by the rapidity of its diurnal motion, form interstices through which the opaque body of the planet becomes visible.

The face of Jupiter is also covered with spots, which, however, from the variations of some of them, and the sensible difference in the period of their rotation, induce an opinion that they are only clouds, which the winds transport with various degrees of velocity, in an extremely agitated atmosphere. Sometimes one or more spots are formed between the belts, which increase till the whole are united in a large dusky belt.

Besides these cloudy indications, some bright spots are to be discovered on the surface of this planet, of a more permanent nature, though subject to disappear and reappear after unequal intervals of time. The remarkable spot, by whose motion the rotation of Jupiter on his own axis was first ascertained, disappeared in the year 1694, and was not again seen till 1708, when it reappeared exactly in the same place, and has been occasionally seen ever since.

Upon the whole, the appearance of Jupiter through a telescope is of the most interesting na-

ture, and opens a vast field for curious inquiry. (*See Frontispiece.*)

Jupiter is attended by four satellites, or moons, which revolve about him at different distances, and in different periods of time. They were first discovered by Galileo, and are visible with a telescope of moderate magnifying power, nearly in a line with the belts on the planet. The nearest of these satellites makes a revolution in less than two days, and the most distant in rather less than seven. From these revolutions, it is evident the satellites, like our moon, are liable to be eclipsed; and, by means of their eclipses, a method has been devised for determining the longitude of places with great facility and accuracy. By the same means, also, is demonstrated the progressive motion of light; the velocity of which is more than a million of times greater than that of a ball issuing from a cannon.*

The greatest ornament of the nocturnal heavens of Jupiter is his group of four moons, or satellites. Their apparent diameters, as seen from the planet, are 31′ 11″, 17′ 35″, 18′ 0″, and 8′ 46″; the first appears nearly as large as our moon. They may sometimes all be seen above the horizon of a

* Rays of light pass from the sun to the earth in about eight minutes and a half, or at the astonishing rate of 11,500,000 miles in a minute. If the sun were suddenly annihilated, we should continue to see him for eight minutes and a quarter afterwards; and if recreated, we should not behold him till eight minutes and a quarter afterwards.

given place at once; but they will much oftener all be invisible.

The following drawing shows the telescopic appearance of Jupiter and his satellites as seen from the earth.

Owing to the proximity of these satellites to their primary, they can never see quite half of his surface at a time. The portion visible at the *first* is 0.414; that at the *second*, 0.446; that at the *third*, 0.466; and that at the *fourth*, 0.481. Jupiter is robbed of the best portion of the light of his moons — viz., that of the full moons — by eclipses.

The satellites revolve from west to east, in planes very nearly coincident with that of the equator of the planet. The latter plane, being inclined only about 3° to the orbit, differs very little from the plane of the ecliptic. Hence, when viewed from the earth, these satellites appear to oscillate to and fro, sometimes passing across the body of the planet, and casting shadows upon his disc; and at others disappearing behind the body, or falling into its shadow, at a distance from the planet. In the former case, Jupiter suffers a solar eclipse; and, in the latter, his moons are eclipsed. (*See the figure of Jupiter and his satellites.*)

The first three satellites are eclipsed at every opposition, or full moon; the fourth may occasionally esca · being eclipsed, owing to the greater inclination of its orbit: this escape, however, occurs very rarely, and all the four moons are eclipsed at nearly every revolution. The first, or nearest satellite, is totally eclipsed every 42½ hours.

Notwithstanding the number of Jupiter's moons, the earth is better provided with moonlight than that planet; for, as has been before stated, the intensity of the light of the sun is only $\frac{1}{27}$ as great there as at the earth; and moreover the first satellite presents a disc about the size of our moon; the discs of the second and third are about one-third, and that of the fourth only one-twelfth, as large: so that their combined light would not be equal to that of our one moon.

There are some portions of the surface of Jupiter which have no moonlight. At the 81st degree of latitude, the first satellite is never seen; at 84½°, the second is never visible; at 86½°, the third; and at 88°, none of them can ever be seen. It is only in the equatorial regions that the moons are of material benefit.

The arc which Jupiter describes by his geocentric retrograde motion, is about 10°; and the time occupied in describing it is 119 days. The retrograde motion begins and terminates when Jupiter's elongation from the sun is about 115°.

The heavenly bodies which may be observed from Jupiter, independently of the sun and fixed stars, are: his own satellites—the planet Saturn, with his ring and satellites—and probably Herschel, with his satellites.

Jupiter, among the heathens, was the reputed

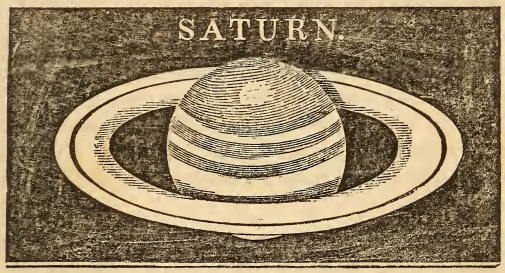
son of Saturn and Rhea, brother and husband to Juno, and king of heaven and earth. His worship was universal, and surpassed in solemnity that of all the other deities. His temples were numerous, and he had many oracles, of which the most renowned were those of Dodona, in Epirus, and Ammon, in the Libyan Desert. His names were numerous; as Osiris, Ammon, Baal, Belus, Zeos, Dios, Jeu, Jeud, Thor, Sanus, Olympius, &c. The oak and the eagle were sacred to him; and he was generally represented on a splendid throne of gold or ivory, with lightning and thunderbolts in one hand, and a sceptre of cypress in the other: his look was majestic; his beard long and flowing; and at his feet stood the eagle with expanded wings. His name seems to be formed of *Io* or *Ion*, the dove, and *Pater*, lord or priest; and his character appears to have been twofold: as *lord of the dove*, or heavenly messenger, which brought to the remnant of the human race, shut up in the Ark, the good news of divine reconciliation, he was an idolatrous representative of the true God; and as *priest of the dove* he may be easily referred to Noah, who offered the first sacrifice after the general Deluge. There were many Jupiters: Varro reckons three hundred, Diodorus mentions two, and Cicero three; but the actions of all were attributed to the son of Saturn and Rhea, who was said to have been born in Crete, and to have reigned on Mount Olympus, between Macedonia and Thessaly. The character used by

astronomers to designate Jupiter, seems originally to have been the letter Z, the first letter of *Zeus*, the Greek name of Jupiter; which in the course of time has been changed to ♃.

## SEC. 20.

### ♄ SATURN.

The tenth planet in order from the sun, moves in an orbit which, during many ages, was considered as the boundary of our system. His mean




distance from the sun is upwards of 906 millions of miles, or more than 9½ times that of the earth. His diameter is 79,000 miles, and his magnitude almost a thousand times that of the earth. His annual revolution occupies nearly 10,759 days, or about 29½ of our years, although he moves at the rate of little short of 21,000 miles every hour. His rotation upon his own axis from west to east is performed in 10 hours 30 minutes; consequently

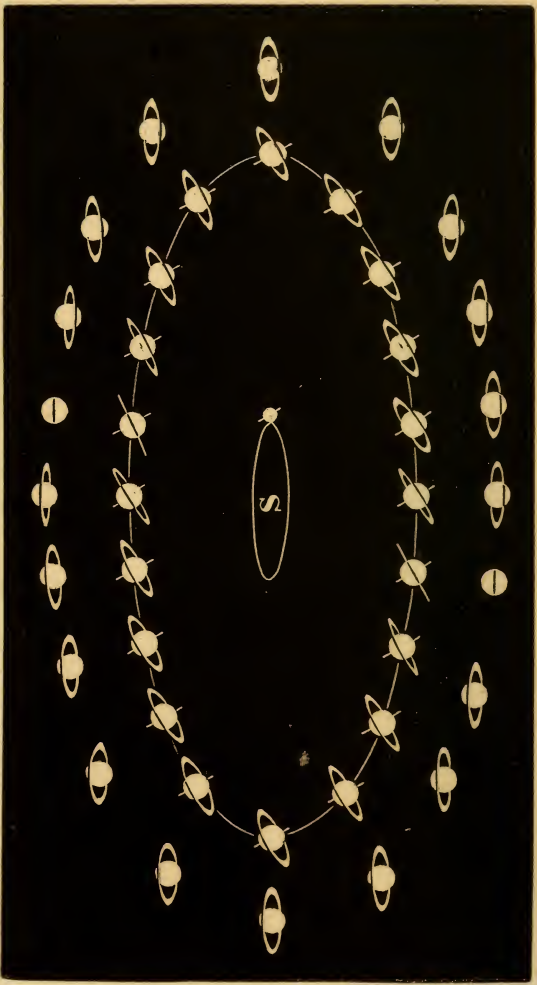
he has more than two days to our one. His orbit inclines to the ecliptic almost $2\frac{1}{2}$ degrees; and his axis is inclined to the plane of his orbit 29 degrees. He shines with a pale lead-coloured light; and the proportion of his polar to his equatorial diameter is as 10 to 11.

Saturn is by far the most wonderful and magnificent member of the solar system. Its apparent diameter, or the angle it subtends, as seen from the earth, is 16″, or about $\frac{1}{120}$, as great as that of the moon. This stupendous globe, besides being attended by no less than *seven moons*, is surrounded with two broad, flat, *rings*, extremely thin, and nearly concentric with the planet.

They lie in the same plane, and are separated from each other by a very narrow interval. That which separates the inner ring from the body of the planet is much wider. The thickness of this extraordinary appendage, according to the younger Herschel, does not exceed 100 miles. The other dimensions, as derived from the observations of Struve, are as follows:

| | |
|---|---|
| Exterior diameter of exterior ring ..... | 176,418 miles. |
| Interior diameter of exterior ring ..... | 155,272 " |
| Exterior diameter of interior ring..... | 151,690 " |
| Interior diameter of interior ring ..... | 117,339 " |
| Equatorial diameter of the body ..... | 79,160 " |
| Interval between the planet and interior ring | 19,090 " |
| Interval between the rings ..... | 1,791 " |

A telescopic view of Saturn is given in the frontispiece. It is surrounded by its rings, and its body is striped with dark parallel belts resembling those of Jupiter, but less strongly marked,




Phases of Saturn.

and owing, doubtless, to a similar cause. That the ring is a solid opaque substance, is evident from the fact that it casts a shadow upon the side of the planet nearest the sun, and on the opposite side the ring receives the shadow cast by the body of the planet, as represented in the figure. From the parallelism of the belts with the plane of the ring, it might be conjectured that the axis about which the planet revolves is perpendicular to that plane; this is found to be the case by observations of spots which are occasionally seen upon its surface, the motions of which indicate a rotation about such an axis in 10h. 29m. 17s., according to Herschel; this period is, however, somewhat uncertain.

The axis of Saturn, like that of the earth, preserves its parallelism to itself during the revolution of the planet round the sun. (*See the drawing.*) The rings rotate about the planet, in the plane of its equator, in nearly the same time as is occupied by the planet in making a revolution about its axis.

Their plane, which is always parallel to itself, is inclined to the ecliptic at an angle of 28° 39′ 45″; and it intersects the ecliptic in two opposite points, called the *nodes of the ring*, whose longitudes or distances from the vernal equinox, are 70° and 350° respectively. In consequence of this obliquity of position, the rings always appear elliptical to us, with an eccentricity so variable that they occasionally appear like a straight line crossing the body of the planet. In the beginning of October, 1832, the plane of the rings passed through the centre of the earth, so that the edge was turned directly

towards us; in that position it is visible only with the most powerful telescopes, and appears like an extremely fine line crossing the disc of the planet, projecting out a little distance on each side of it. The rings are in this position twice during every revolution of Saturn round the sun, or at intervals of about 15 years, near the time when the planet is in the longitude of one of the nodes of the ring. At that time the plane of the ring passes through the centre of the sun, and the edge only is illuminated: this phenomenon occurred about the middle of December, 1832. The earth generally passes through the plane of the ring twice within a few months of the time when the planet is in longitude 170° or 350°; accordingly the rings vanished again in the end of April, 1833. As the planet recedes from one of these points of its orbit, the line of sight becomes gradually more and more inclined to the plane of the ring, which appears to open out by degrees into an ellipse which attains its greatest breadth when the planet is 90° distant from one of these nodes, or in longitude 80° or 260°. At the time of its greatest opening, the longest diameter is just twice as great as the shortest. The figure represents the form of the ring as seen from the earth, E, at different periods, throughout a revolution of Saturn round the sun, S.

It is a singular result of theory that the rings could not maintain their stability of rotation, if they were everywhere of uniform thickness and density; for the smallest disturbances would destroy their equilibrium, which would become more and more deranged, till, at last, they would be precipitated on the surface of the planet. They must therefore be irregular solids, so that their centres of gravity do not coincide with the centres of their figures. Professor Struve has discovered that the centre of the ring is not exactly

coincident with the centre of Saturn, the angular distance between the two centres being about $\frac{1}{5}$ of a second.

The rings of Saturn must present a most magnificent spectacle in the firmament of that planet, as vast arches or semicircles of light extending from the eastern to the western horizon, occupying a large portion of the visible sky. Their appearance varies in different regions of the planet. At about 37° distance from the equator, on the side towards the sun, they are seen in their greatest splendour, as semicircles stretching across the heavens. In the daytime they appear dim, like a cloud, or like our moon when the sun is above the horizon. After sunset their brightness increases, and the shadow of the planet is seen on the eastern part of the ring directly opposite the sun; as the night advances, this shadow moves gradually along the ring till it disappears in the west at sunrise. On the equator, only the inner surface of the interior ring is visible as a very narrow belt extending from the eastern through the zenith to the western point of the horizon. In the polar regions of the planet only a small portion of the rings is visible, and at the poles they are never seen.

During half of Saturn's year, or nearly fifteen of our years, the sun shines on one side of the rings without intermission. The portion of the surface of the planet on that side of the equator is, therefore, enlightened by the sun in the day-

time, and by the rings at night, while the portion of the other hemisphere lying under the dark side of the ring, suffers a solar eclipse of fifteen years' continuance.

Saturn's very long year of 10,759 terrestrial days consists of 24,591 Saturnian days. It is divided into four seasons, as follows:

| Northern Hemisphere. | Southern Hemisphere. | Terrestrial Years. |
|---|---|---|
| Spring | Autumn | 7.74 |
| Summer | Winter | 8.01 |
| Autumn | Spring | 6.94 |
| Winter | Summer | 6.76 |

The intensity of light at Saturn is from 81 to 101 times as weak as at the earth. The apparent diameter of the sun varies from 3′ 33.2″, to 3′ 10.6″; or, it is a little more than $\frac{1}{10}$ his diameter as seen from the earth.

The force of gravity at the surface of the earth being called 100, that at the pole of Saturn is 135; the fall of a body during the first second is 21.664 feet, and 1 pound weighs there 1 pound 5½ ounces. At the equator, in consequence of the compression of the planet at the poles, and its rapid rotation, the fall is 12.384 feet in the first second, and a pound only weighs 12½ ounces. The length of the seconds pendulum is 2.51 feet at the equator, and 4.39 feet at the poles; so that the observations of the length of the pendulum affords to the inhabitants of that planet a good means of determining Saturnigraphical latitudes.

The apparent diurnal motion of the heavens is nearly as rapid for Saturn as for Jupiter, and for each place on the surface of the former planet, a certain zone of stars will be constantly eclipsed by the rings, except in the polar regions, where the rings are invisible.

The nocturnal heavens of Saturn are adorned by seven satellites, whose diameters are quite unknown to us, but we may with some degree of certainty assume, that their united discs, as seen from Saturn, would not form one as large as that which our moon presents to us.

The diameter of the most distant satellite but one (sometimes called the Huygenian Satellite,) has been estimated at about 2700 miles; hence it appears at Saturn under an angular diameter of 8′ 40″; supposing the last or most distant moon to be of the same magnitude as of the Huygenian, its apparent diameter would be only 3″.

In reference to the phases which these moons present to their primary, they differ essentially from the satellites of Jupiter and our moon. With the latter, the inclination of their orbits to those of the primaries is too small to produce any remarkable difference in the various phases at different seasons of the year. But it is not so with Saturn; it never has a perfect full moon or a perfectly invisible new moon, except at those seasons of its year when it is near one of the nodes of the plane of its ring, which is nearly the plane of the orbits of its moons; at all other seasons there remains at the

opposition of either of the moons, a small portion of the northern or southern border of the disc of the moon unilluminated, and when the moons are in conjunction, a small portion of the northern or southern border is illuminated. The breadth of this part is at a maximum when Saturn is 90° from the nodes of its rings.

As is well known, our moon passes the meridian of a given place, about 50 minutes later each night than the preceding, owing to its motion being in a direction opposite to that of the apparent daily motion of the heavens. The first or nearest satellite of Saturn revolves around that planet in $22\frac{3}{4}$ hours, in a direction opposite to that in which the heavens appear to make a revolution in $10\frac{1}{2}$ hours, so that when this satellite, as a full moon, passes the meridian of any place on the surface of Saturn at midnight, it will not come to that meridian again until $19\frac{3}{4}$ hours afterwards, or the second night after, at $1\frac{3}{4}$ hours before midnight. Or, in other words, the first satellite of Saturn passes the meridian of a given place at intervals of a little less than two of Saturn's days.

Owing to the great inclination of the ring and of the orbits of the satellites to the ecliptic, or orbit of Saturn, the eclipses of the moons can happen only at those seasons when the planet is in the neighbourhood of one of the nodes of the ring. During a period of $6\frac{1}{2}$ of our years, at the middle of which time Saturn is in one of these nodes, the innermost satellite is eclipsed every full moon; and for about $8\frac{1}{2}$ years, preceding and following this period, it cannot be eclipsed. The periods during which eclipses of the other satellites will occur, are much smaller; for the Huygenian, or sixth satellite, it is only one year; and for a period of 13.7 years, or nearly a half of Saturn's year, it suffers no eclipse. Eclipses of the sun, caused by these satellites, are phenomena of almost daily occurrence, about the time when Saturn is in one of the nodes of its ring.

These seven satellites, owing to their great distance from us, appear much smaller than those of

Jupiter, and for their observation much larger telescopes are requisite. Their theory is for the same reason less perfect. The most distant satellite is the largest, it being probably not much less than Mars. Its surface, like those of the satellites of Jupiter, presents a varying light, from observations of which it has been concluded that it performs a revolution about its axis and one about Saturn in the same period of time. The plane of its orbit is sensibly inclined to the plane of Saturn's ring, whilst the planes of the other orbits lie very nearly in the plane of the ring. The sixth satellite is next to the seventh in magnitude. The others are very much smaller, and the first three so small as only to be visible through the very largest telescopes, and even with such instruments they can only be seen under the most favourable circumstances. Sir William Herschel has seen them at a time when the ring had disappeared to all other observers; but they appeared to him, through his great telescope, as extremely small bright spheres upon a very fine line of light.

The times of revolution of these satellites, and their mean distances from Saturn in terms of his equatorial semi-diameter, are given below.

| | | Time of Revolution. | | | | Mean Distance. |
|---|---|---|---|---|---|---|
| 1 | Satellite | 0d. | 22h. | 36m. | 18s. | 2.4682 |
| 2 | " | 1 | 8 | 53 | 3 | 3.2079 |
| 3 | " | 1 | 21 | 18 | | 5.284 |
| 4 | " | 2 | 17 | 45 | | 6.819 |
| 5 | " | 4 | 12 | 25 | | 9.524 |
| 6 | " | 15 | 22 | 41 | 25 | 20.7060 |
| 7 | " | 79 | 7 | 55 | | 64.359 |

The orbits of the third, fourth, fifth and seventh, are but little known; those of the first and second somewhat better; and that of the sixth best of all. That of the second has no sensible eccentricity. The eccentricity of the first is 0.06889; and the longitude of the point nearest Saturn is 104° 42′.

In the language of the mythologists, Saturn was the son of Uranus, otherwise Cœlus, and Terra, *i. e.* of Heaven and Earth, and the father of Vesta, Ceres, Pluto, Neptune, Jupiter, and Juno. His reign is represented as so mild, beneficent, and virtuous, that it obtained the title of *the golden age*. He is generally represented as a decrepit old man, holding in his right hand a scythe, and a serpent in a circular form biting its own tail,—emblems of the ravages of time and the revolution of the year. In his left hand, he holds a child, as if about to devour it, to denote that time consumes its own productions. He also bore the names of Sator, Ilus, and Chronus; and his festivals, called Saturnalia, were celebrated about the time of the winter solstice, to commemorate the freedom and equality which prevailed on earth during his reign. Some have supposed that Saturn was an apotheosis of the patriarch Noah, others of his son Ham; but Macrobius assures us that his name was a Phœnician title of the sun. The astronomical sign of Saturn, ♄, is supposed originally to have represented a scythe.

## SEC. 21.

♅ HERSCHEL, OTHERWISE URANUS, OR GEORGIUM SIDUS.

This planet was discovered by Sir William Herschel, on the 13th of March, 1781. In honour of his royal patron, George III., he gave it the name of *Georgium Sidus,* or *Georgian Star;* but by foreigners it is frequently called *Herschel,* in honour of its discoverer; and the Royal Academy of Prussia, with some others, called it *Uranus,* from the circumstance of the other planets being named from such heathen deities as were reputed relatives: thus *Uranus* was the father of Saturn, *Saturn* the father of Jupiter, *Jupiter* the father of Mars, &c. Pleasing as this analogy may appear, the appellation of *Herschel* is quite as appropriate, inasmuch as it is an honour justly due to the ingenious and persevering discoverer.

Herschel is the most remote planet yet discovered in our solar system. He is rarely to be seen but through a telescope; but in a clear night, when the moon is absent, he may be seen by the unassisted eye, about the size of a star of the sixth magnitude, of a bluish white colour, with a brilliancy between that of Venus and the moon.

The mean distance of this planet from the sun is upwards of 1,822,000,000 of miles, or about 19 times the distance of the earth. His diameter is variously stated at 34,170 and 35,865 miles, and

his bulk is 80 times as great as that of our earth. He moves nearly in the plane of the ecliptic, the inclination of his orbit being somewhat less than $46\frac{1}{2}$ minutes.

This planet performs his annual revolution in nearly 30,689 days, or rather more than 84 of our years, moving from west to east at the rate of 15,546 miles per hour. His rotation upon his axis is performed in about $1\frac{3}{4}$ of our days.

Our knowledge of this, the most distant planet of the system, is too limited to enable us to give a very detailed account of its peculiarities. It receives from the sun, when nearest that body, $\frac{1}{334}$, and when most distant $\frac{1}{403}$ as much light as the earth.

The apparent diameter of the sun, as seen from Uranus, or Herschel, varies from 1′ 36″ to 1′ 45″; the apparent disc of the sun is only $\frac{1}{360}$ as great there as at the earth. Its light at that planet is about midway between our sunlight and our moonlight.

The situation of Uranus is unfavourable for obtaining a knowledge of the solar system. Even Saturn appears at Uranus smaller than at any other planet of the system, and Jupiter appears hardly as large there as Mercury does to us. All the other planets are, with reference to Uranus, *inferior*, and may occasionally be observed from that planet upon the sun's disc; these transits are, however, of very rare occurrence; a transit of Saturn will not happen oftener than once in 10,000 of our years. The moons of Uranus and the fixed stars are the only bodies visible in his midnight heavens.

Vast as is the distance of Uranus from the earth, it must not be supposed that the fixed stars appear larger or nearer than they do to us; for the distance of this planet from the

earth is less than one thirty-thousandth part of that of the nearest fixed star known; the former distance is to the latter what the height to which an æronaut soars is to the distance of the moon.

The *annual parallax* of the fixed stars, or, the angle contained between two lines conceived to be drawn from a star, one to the sun and the other to the planet, is nineteen times greater for Uranus than for the earth. This angle is, for the nearest fixed star, but a small fraction of a second at the earth, whilst at Uranus it amounts to several seconds. So that the problem of finding the *Annual* parallax and distance of the fixed stars, which so long baffled all the attempts of our astronomers to solve it, but which at last yielded to the genius of Bessel, presents very little difficulty to the Uranians, except that which arises from the length of one of his years, required to complete an observation. This is the only point in which the latter astronomers have an advantage over those of our earth.

The greatest peculiarity of the Uranian system is that the orbits of the satellites are nearly perpendicular to that of their primary, and their motions are in a *retrograde* direction, that is, from east to west; while the satellites of all the other planets revolve from west to east around their primaries, in paths but slightly inclined to those of the latter.

We have already seen that, in the variation of their phases, the moons of Saturn differ from those of Jupiter and the earth; but this difference is very small in comparison with that which the position of the paths of the satellites of Uranus causes in their phases when compared with those of Jupiter and the earth. When the planet is near 90° from the

node of the orbit of one of its moons, that moon will be continually in quadrature, or nearly so, and will present either a little more or a little less than half its illuminated side towards its primary, during a period of several revolutions of the satellite: its phase will be nearly like that which our moon presents a day before or after its quarter. On the other hand, when Uranus is at or near one of the nodes of the lunar orbit, the moon will present to it the same succession of phases each revolution, as our moon presents to us. At that time also, Uranus may experience eclipses of that moon, and eclipses of the sun by it.

In consequence of the positions of their orbits, these satellites suffer and cause eclipses of the sun much more rarely than those of Saturn or Jupiter. At intervals of a half year of Uranus, or about forty-two of our years, when the planet is at the nodes of its moons' orbits, there will occur a series of eclipses, which may amount, for all the moons, to about 200 of each kind. The first, or nearest, moon begins the series, and the others follow in the order of their distances from the primary. The whole series occupies a period of about two of our years, and during the succeeding interval of forty of our years, there are no eclipses.

In density, Uranus is surpassed by all the other planets except Saturn. A pound at the earth weighs there 12½ ounces; and the fall of a body during the first second is 12.29 feet.

The approximate distances of the satellites, the periods of revolution and positions of the orbits of two of them, and the periods of the others, deduced by means of Kepler's third law, constitute our whole knowledge of these bodies. Their distances and periods are as follows:

| | Distances. | Periods. | | |
|---|---|---|---|---|
| 1 ..... | 224,000 miles ..... | 5d. | 21h. | |
| 2 ..... | 291,000 " ..... | 8 | 16 | 56m. |
| 3 ..... | 340,000 " ..... | 10 | 23 | |
| 4 ..... | 390,000 " ..... | 13 | 11 | 9 |
| 5 ..... | 777,000 " ..... | 38 | 2 | |
| 6 .....1 | 556,000 " ..... | 107 | 17 | |

The existence of the second and fourth of these moons is certain; they have been observed by Lamont and the younger Herschel, and their orbits are pretty well determined; but the others have never been seen by any one except Sir William Herschel, and their existence is by no means certain.

Uranus, or Ouranus, was esteemed by the heathen mythologists as the most ancient of all the gods, although he was allowed to have had progenitors, who were also deities. His father was called Acmon, otherwise Eliun, or Hypsistos, and was worshipped under the title of the *Most High;* and his mother was Beroë, otherwise Beroth, or Beryth. Uranus, who also bore the names of Epigæus-Autochton and Cœlus, is said to have married his sister Ge or Terra, otherwise Tithea or Tellus, and was father to the Titans, Cyclops, and Giants, all personages of great renown in the mythologic legends. Though a god, he was deposed by his son Saturn, one of the Titans, who in process of time was deposed by his own son Jupiter. Uranus seems to have been a personification of universal space, the identification of which with the Omnipresent Deity, there is good reason to believe, formed, even prior to the Deluge, the first heresy in religion, and led to all the melancholy results of idolatrous polytheism. The astronomical sign of this planet is the letter H, indicative of its discoverer, with the figure of a planet suspended from its cross-bar, ♅.

## SEC. 22.

### COMETS.

Besides the eleven planets, and their eighteen satellites, there is a multitude of other bodies, called *comets*, which belong to our solar system, and make their revolutions round our sun. They are called *cometæ*, *hairy bodies*, or *comets*, from the appearance of their tails.

The number of comets on record is about 500. Of these, the first 450 are mentioned in ancient annals and chronicles. The rest have been seen in the last hundred years, chiefly by the aid of the telescope. When we reflect that no comet was noticed by the common people from 1769 to 1807, a period of 38 years—though 36 were seen in telescopes, and their orbits computed by astronomers—we readily perceive the defectiveness of the list. The experience of the past few years shows that an attentive examination of the heavens with telescopes, brings to our view about three comets in a year. To this number may be added at least one for each year, so situated with respect to the earth as to be invisible in its approach to and departure from our system. According to this estimate, 24,000 comets must have visited the solar system since the creation. When we extend our views farther, and consider that Jupiter is at the remotest distance from the sun

at which comets are ever visible to us, and that the active force of gravity of our sun extends through a sphere whose radius is more than a million of times the distance of Jupiter, we must conclude that the number of comets which in the immensity of space still obey the controlling power of our sun is almost countless. We may safely estimate them by *hundreds of thousands*, and probably by *millions!*

The purpose for which these singular bodies were created, is as little known to us as is the nature of their internal organization. As far as we can judge from their appearance, they are composed of three principal parts, *the head, the nebulous envelope,* and *the tail.*

### THE HEADS OF COMETS.

The head is comparatively small, seldom greater than our moon. In some comets it is altogether wanting. It usually appears less bright than even the planets, and is of a pale whitish colour.

The following estimates have been made of the size of the heads of comets.

| | | | | | |
|---|---|---|---|---|---|
| The Comet of | 1798, | diameter of the head | | 33 | miles. |
| " " | 1805 | " " | | 36 | " |
| " " | 1799 | " " | | 462 | " |
| " " | 1807 | " " | | 666 | " |
| " " | 1811 | " " | | 3267 | " |

### THE NEBULOUS ENVELOPE.

The *nebulous envelope* is the only universal

characteristic of comets. It has the appearance of a thin cloud of condensed vapour or smoke, surrounding the head of the comet when visible. It is gradually thickened towards the centre when no head is to be seen. Some comets which to the naked eye and in small telescopes have seemed to have a head, have, when greatly magnified in powerful telescopes, been wholly resolved into a cloudy-looking substance or nebulous envelope.

### THE TAIL.

The *tail* of comets is usually the prolongation of the *nebulous envelope* in a direction from the sun. Sometimes the *tail* is wanting, and then the *nebulous envelope* is somewhat oval, or fan-shaped, with the densest portion not in the centre, but nearer the sun than the centre of the figure. The portion next the sun is in such cases rounded, the portion from the sun slightly elongated, and its outline not well defined. Sometimes the tail extends to a great length, and it is often bent concavely on the side which is towards the point of the orbit which the comet is leaving. In such cases the concave border is better defined and smoother than the opposite or convex border.

Some comets have had two tails. That of 1823, for instance, had one tail extended towards the sun, the other from it. The comet of 1744 had six tails, each about 4° in breadth, and 30° or 40° in length. Chladni noticed a rapid short-

ening and lengthening of the tail of the great comet of 1811, which amounted to several millions of miles in a second, a velocity of motion (if mo tion it was) far exceeding that of light. Many other astronomers have recorded similar appearances. They are not, however, considered to be well established.

The comet which appeared 371 years before Christ, is said to have covered a third part of the visible heavens. That of 43 years before Christ, was so bright as to be seen in the day-time. It was supposed to be the ghost of Cæsar, who had just been assassinated. Seneca mentions a comet in A. D. 60, which eclipsed the brightness of the rising sun. In 1402, two comets appeared; the one was seen in the day-time, in March; the other in June following, long before sunset. The tail of the comet of 1456 was 60° long. That of 1618, 100°, so that its tail had not all risen when its head reached the middle of the heavens. The comet of 1680 was so great, that though its head set soon after the sun, its tail, 70° long, continued visible all night. The comet of 1689 had a tail 68° long. That of 1744, which had six tails, had a head brighter than Venus, and could be seen with the naked eye an hour after midday. That of 1769 had a tail more than 90° in length. That of 1811 had a tail 23° long. The recent comet of 1843 had a tail 60° in length.

These estimates are the angles under which the tails were seen from the earth. The real lengths

of several comets' tails have been estimated as follows:

| | | |
|---|---|---|
| Tail of Comet of | 1680 ..... | 123,000,000 miles. |
| " " | 1744 ..... | 35,000,000 " |
| " " | 1769 ..... | 48,000,000 " |
| " " | 1811 ..... | 130,000,000 " |
| " " | 1843 ..... | 130,000,000 " |

### ORIGIN OF THE ENVELOPE AND TAIL OF COMETS.

The tails of comets owe their origin to the action of the sun. They are usually directed from it. They increase as the comet approaches the perihelion, and decrease soon afterwards; and usually disappear before the comet has attained a distance of 200,000,000 of miles from it.

The physical observations of Olbers on the comet of 1811, and of Bessel and Arrago on Halley's comet in 1835, have given us some insight into the nature of these bodies. Professor Norton, of Newark, Delaware, has recently, from his own researches, been led to conclusions similar to those of Olbers and Bessel.

According to Arago, they shine by reflected light; and according to Olbers and Bessel, the nebulous envelope is formed by a repulsive force in the substances on the surface of the solid portion or head. It is quite probable that when at their greatest distance from the sun or aphelium, the heads, owing to the condensation of the volatile portions through extreme cold, become solid bodies like our earth.

On nearer approach to the sun, the effect of its heat or light, or of both, is such as to volatilize the substances on its surface. These volatile substances do not resemble the gases or vapours on the earth's surface; for they have no power of refracting the sun's rays. They may rather be compared to the particles of dust thrown off by electrical repulsion from

an excited conductor. In other words, the force which governs the distance of these volatile particles from each other, seems to be that of *polarity*, and not of *elasticity*. In many instances, stars have been seen through the densest portions of comets. This is explained by supposing that the force of polarity or repulsion is so great as to overcome that of cohesion of the particles, and reduce the substances, which would otherwise be solid, to a state of thinness or subtility, exceeding that of the most volatile essences known to us. In this manner, the formation of the envelope has been supposed to be accounted for. The formation of the tails of comets is attributed to a second or *solar polarity*, acquired by the particles that have, by the first polarity or electrical repulsion, been scattered about so as to form the envelope. As the comet approaches the sun from the frozen regions of space, the particles, besides being thrown off from the comet, are also repelled by the sun. Hence, in the direction from the comet and from the sun, they are moved by a double repulsive force, while, towards the sun, they feel only the difference of these forces.

This explains the shape of the envelope and tail. The position of any particle of the envelope or tail at the time when we look at it, depends upon the time when it acquired its *first polarity*, so as to be thrown off from the head of the comet; the particular direction in which it was thrown; the degree of force in this direction; the direction and velocity of its *orbital motion* at the time of separation from its cohesion with the head of the comet; the time when it acquired its second or *solar polarity*, so as to be thrown off in a direction from the sun; and finally upon the degree of repulsive force in that direction.

All these circumstances vary every instant for the same comet, and are different for different comets. It is supposed that their various combinations will account for all the various shapes of comets.

When the *first* or *cometary polarity* is very feeble, and the

second or *solar polarity* very powerful, the tail is long and narrow, as in 1668, 1689, and 1843. (*See the drawing of the comet of* 1843.) When, on the contrary, the comet's head is greater, and the cometary repulsion greater in comparison with the sun's repulsion, the tail is broader, and the portion of the envelope towards the sun extends farther from the head, leaving an almost vacant space between the border of the envelope and the head. The shape of the nebulous envelope and tail, is usually that of a hollow *hyperboloid.* (*See the drawing of the comets of* 1811 *and* 1819.)

### WASTE OF THE SUBSTANCE OF COMETS BY DISSIPATION IN SPACE.

The particles that form the tails of comets, and the extreme portion of the envelope, having passed beyond the sphere of active attraction of the head, can never return, but wander in space, till they become too thin to be seen, and are lost to our view and our knowledge.

Comets that return often to their perihelion seem to lose those particles that are capable of *secondary* or *solar polarization*, and have no tails. Such is the case with Encke's and Gambart's comets. Halley's comet in its recent returns is far less terrific than under similar circumstances in ancient times.

It is impossible to conjecture what becomes of the particles of comets thus thrown off and dispersed through space. If the solar repulsion continues, they must move off in hyperbolas to the confines of the system, perhaps to join with other nebulæ, other systems, or other planets, to revolve round other suns in a more *friendly* relation.

### POPULAR SUPERSTITIONS RESPECTING COMETS.

The appearance of comets in ancient times was always a source of alarm. They were supposed, without just foundation, to be the forerunners of the direst calamities, wars, famine, pestilence,

Great Comet of 1811.

Great Comet of 1819.

deaths of great men, &c. So great was the alarm in christendom in 1456, during the appearance of Halley's Comet, that Pope Calixtus, believing it to be the instrument of Divine wrath, ordered prayers to be offered up in every town, and the bells to be tolled at noon of each day, to warn the people to supplicate the mercy of heaven. He at the same time excommunicated both the comet, and the Turks, whose armies had lately proved victorious against the Christians, and established the custom, which still exists in Catholic countries, of ringing the church-bells at noon.

Comets have also been supposed to produce irregularities in the seasons. When we reflect, that probably no season passes by without our having at least one comet as near to us as Jupiter, we find no just grounds for attributing to this source any of the calamities with which mankind are occasionally afflicted.

Another source of apprehension with regard to comets arises from the possibility of their striking our earth. It is quite probable that even in the historical period the earth has been enveloped in the tail of a comet. It is not likely that the effect would be sensible at the time. The actual shock of the head of a comet against the earth is extremely improbable. It is not likely to happen once in a million of years.

If such a shock should occur, the consequences might perhaps be very trivial. It is quite possible that many of the comets are not heavier than a

single mountain on the surface of the earth. It is well known that the size of mountains on the earth is illustrated by comparing them to particles of dust on a common globe.

The comet of 1770, which approached so near to Jupiter as to have its orbit and period completely changed, produced no sensible effect on the satellites of that planet. It is by no means uncommon for one of the planets to alter a comet's period round the sun by more than a month, while at the same time that of the planet itself is never changed by the comet a single second.

### THE ELEMENTS OF THE ORBITS OF COMETS.

In describing the orbits of the planets, six elements are usually mentioned. This cannot be done with the greater part of the comets: the longer axis and period are unknown. The remaining five elements are the same with comets as with planets.

The average of all the inclinations of the planes in which the comets now on record have been found to move is about 90°, a wonderful instance this of the goodness of Providence in causing their motions to be performed in the manner least likely to come in contact with the earth and the other planets!

The shape of their orbits is also usually that of very flattened ellipses or parabolas, so that they approach the sun and again quickly depart from the limits of the planetary system, and

remain for years, or centuries, or ages, beyond the limit of our vision, even with the best telescopes, another instance of the protecting care of an all-pervading Providence!

The paths of most of the comets may be well represented by assigning to them a parabola for their orbit. In fact the small portion of the orbit in which we see them near their perihelion, is almost the same in a parabola as in an ellipse. Yet it is probable that they all move in ellipses, and have their stated periods round the sun, embracing all varieties, from a few years to many centuries. Among a million of possible combinations of original projectile force, direction, and position with respect to the sun, with which a comet may have been endowed at creation, there is only one that would produce a *circle* or a *parabola* for its orbit. The remaining combinations would produce *ellipses* or *hyperbolas*. The latter curve is, at present, extremely improbable; for if any comets have moved in hyperbolas, they can never have made but one visit to our system, and most of them must ere this have finished their revolution in this system, and be far on their way to another. Still astronomers are occasionally led in their investigations to hyperbolas for the orbits of comets. This circumstance occurred several times in the researches of the celebrated French astronomer Burckhardt. Such irregularities are usually ascribed to the imperfection of our observations of the places of the centre of the comet's head. Our estimate is liable to be biassed by its eccentric position in the nebulous envelope.

It is possible that a comet may approach from an immense distance towards the sun in an elliptic orbit, while its head remains solid. If on its nearer approach to the sun its envelope is formed by the particles thrown off from the head, little change will be produced in its orbit. But when the *solar repulsion* of a portion of the envelope is induced, the effect of this repulsion on the particles not yet beyond the sphere of

active attraction of the comet, must tend to increase the eccentricity of the orbit. In comets like that of 1843, where the solar repulsion is very powerful, and where the head is almost wholly resolved into nebulous envelope, the effect of the sun's repulsion may be sufficient when the comet is near the sun, and the ellipse is very eccentric, to change the instantaneous orbit into a portion of an hyperbola; and again the comet may, on departure to a sufficient distance from the sun for the solar repulsion to cease or be much weakened, resume its elliptic orbit, and having attained its greatest distance from the sun, again return to experience similar changes and modifications. In the case of the comet of 1843, the nicest observations which could be made with the choice instruments at the High School Observatory for a period of 20 days, lead, on sound principles of computation, to an hyperbola for its orbit. This result may have been owing to the imperfection of the observations, or possibly to the circumstance just mentioned.

## PERIODICAL COMETS.

Although it is probable that all the comets move in *ellipses* so eccentric as nearly to resemble a *parabola*, yet few of their periods have been determined. Some revolve in orbits of several thousand years. Perhaps the average period is not far below one thousand. The elements of all the comets whose places have been observed, are computed and preserved in catalogues in order to detect their future returns. The list of comets thus registered, amounts to about 150. Whenever a comet appears whose elements are the same as those of any of the comets in the catalogue, it is presumed to be identical, and the in-

terval since the recorded appearance is considered as constituting one or more periods.

### HALLEY'S COMET.

This comet revolves round the sun from east to west in $75\frac{1}{2}$ years, in an elliptic orbit inclined 17° 44′ to the ecliptic. Its least distance is 56,000,000 and its greatest 1,710,000,000 of miles. Its eccentricity is 0.97. It bears the name of Halley, who discovered its period. In its perihelion, it approaches nearer the sun than Venus, and in its aphelion it departs to the distance of Uranus. It remains within the orbit of the earth at its perihelion $2\frac{1}{2}$ months; but its orbit is so situated that it never approaches within several millions of miles of our planet.

### SUPPOSED APPEARANCES OF HALLEY'S COMET.

The earliest recorded appearance of Halley's comet is supposed to have been 138 years B. C. This would be the 26th period prior to its recent visit in 1835. After an omission in the chronicles for five periods, we find mention of a comet in A. D. 323, at the time of the famous Council of Nice, in the reign of Constantine. Its next return, in 399, occurred during the session of the Council of Alexandria, the year in which the Vandals overran southern Europe. Its appearance is described as being "exceedingly terrific, of great magnitude, and with its tail extending

down to the earth." After two periods, it again appeared in 547, the year in which Rome was plundered by Totilas.

Its *fifth* recorded appearance was in 930, after an interval of four revolutions. At this time it was considered the forerunner of the death of Henry the Fowler, and the subjugation of Hungary. Its *sixth* and *seventh* appearances were in 1005 and 1080, the latter being the year of the death of the Emperor Alexius Comnenus. The *eighth* appearance was in 1155, during the Council of Soisson. The *ninth* is mentioned in 1231, in the Chinese Annals. The *tenth* was in 1305: its appearance was then the cause of general alarm, and was followed by a severe winter, and by a plague which raged in Europe for several years. It is supposed to be one of the two comets which appeared in 1379 and 1380. These eleven appearances are inferred chiefly from a coincidence in dates. For want of astronomical observations, they will always be subject to doubt.

### CERTAIN APPEARANCES OF HALLEY'S COMET.

The first *certain* appearance was in 1456: its tail was 60 degrees in length, and broad like a peacock's tail, as has been already noticed. Its next undoubted appearance was in 1531. The third was in the time of Kepler, in 1607. It traversed the northern constellation as in 1835. Its fourth appearance was in 1682, in the time of

Newton, when it was regarded as a friendly visiter, and not as the harbinger of Divine wrath.

Its period was soon after ascertained by Halley, who computed the elements of all the comets on record, and found that three of them, viz. those of the great comets of 1456, 1531, and 1607, had similar elements to those of the comet of 1682. Accordingly, he assigned to it a period of 76 years, and predicted its return in 1758. In reality, it returned in 1759, having been retarded 100 days by Saturn, and 518 by Jupiter, according to the subsequent predictions of Clairaut. In 1835, its return was predicted by eminent astronomers early in November. It actually came to its perihelion on the 16th. The period of this comet is now well established, and its return early in the next century will doubtless be foretold within a single day.

### OLBERS'S COMET.

This comet was discovered by Olbers in 1815. It revolves round the sun in 75 years. Its orbit is inclined 44° to the ecliptic. Its least distance is 116,000,000 and its greatest 1,557,000,000 of miles; its eccentricity being 0.93. Its orbit is so situated that it can never come very near the earth. It will return to its perihelion about the 9th of February, 1887. It is a small faint comet and has probably escaped notice in its former returns.

## ENCKE'S COMET.

Encke's comet, or *the comet of short period*, revolves round the sun in 1210 days, in an orbit inclined 13° 22′ to the ecliptic. Its eccentricity is 0.854. Its least distance from the sun is 31,000,000 of miles, being within the orbit of Mercury. Its greatest distance is 390,000,000 of miles, being between the orbits of the Asteroids and Jupiter.

It was discovered by Pons in 1819, but its period was first ascertained by Professor Encke. It had been seen by Messier and Mechan in 1786, by Miss Caroline Herschel in 1795, and by all the astronomers in Europe in 1805. Its returns in 1825, 1828, 1832, 1835, 1838, 1842, have all been observed, and its place is now computed in advance almost as well as that of the planets or asteroids. In 1838, it was visible to the naked eye as a nebulous star of the 4th magnitude. It has no tail, though its nebulosity is always manifest, and in 1838 extended through several minutes. The densest portion of the nebulosity is always eccentric in its position in the envelope, being nearer to the sun than the centre, and having the portion from the sun somewhat fan-shaped.

The perihelion point of the orbit of Encke's comet falling just within that of Mercury, and being only 3° from its descending node, if it passes that point when Mercury is in the sign of the Virgin, they must approach near each other. This combination occurred in 1838, and furnished Encke the

means of determining the mass of Mercury, more precisely than it was known before.

This comet is found to encounter a slight resisting medium in its path for a few months before and after the perihelion passage. This takes place while it is within the orbit of Venus.

As this resistance tends to weaken the tangential or centrifugal force of the comet, the attractive or central force of the sun gains continually on it, increases its angular motion, shortens its period, and diminishes its mean distance.

This quickening of the angular motion is such, that the comet advances in each revolution *one minute* of space farther in its orbit, than it would do by Kepler's Laws if it moved in a perfect void. This advance brings the comet back to its perihelion, each time, one hour and twenty minutes sooner than before. The accumulation of these advances since 1785, in 17 revolutions, to 1842, amounts to about $17\frac{1}{5}$ days, a quantity too great to be reasonably ascribed to any other known cause, for the want of which the theory of a resisting medium in the planetary spaces between Venus and the Sun, is resorted to as a matter of necessity.

Bessel has shown that there are many other causes known to exist, which are capable of producing an acceleration in the mean motion of Encke's comet; but Encke remarks with reason, that each of the causes enumerated by Bessel, would produce other effects which we do not notice in the case of the comet of short period. The grounds for adopting the Enckian theory of a resisting medium, are similar to those in favour of the Copernican system, viz: that it explains all the observed facts, and that no other hypothesis will.

Encke assumes that the density of this medium increases as the square of the distance from the sun diminishes, and that it resists the comet with a force increasing as the square of the comet's orbital velocity increases. It is not known of

what substance this resisting medium is composed, or by what means it maintains its distance from the sun. Some have supposed it to be the zodiacal light, or nebulosity which surrounds the sun; others have supposed it to be the source of the periodical meteors, each of which has been considered an independent asteroid, revolving round the sun in its own orbit, the average number of them in any portion of space increasing, by the same law as the resistance increases.

Encke's comet will return to its perihelion early in August, 1845, and late in November, 1848. In 1845 the visit will be under unfavourable circumstances for observation.

### GAMBART'S COMET.

This was discovered on the 27th of February, 1826, by M. Biela; but M. Gambart, of Marseilles, first ascertained that its elements were the same as those of the comets of 1772 and 1806, and hence that its period was 2460 days, or about $6\frac{2}{3}$ years. It is inclined 13° to the ecliptic. Its eccentricity is 0.75; its least distance is 86, its greatest distance 586 millions of miles, being situated between the orbits of Venus and Saturn.

It is possible that this comet, as well as Halley's, experiences the effect of the resisting medium. Halley's comet only approaches to the orbit of Venus, and Gambart's to that of the earth, distances at which Encke is unable to detect any resistance to the motion of his comet. Even if this medium extends beyond the earth, the elements of Halley's and Gambart's comets are not known with sufficient precision to detect such a resistance.

Gambart's comet was seen in its return to its perihelion in 1826, but not in 1839, verifying, in this respect, the predictions of Santini, who found from a computation of its ephemeris that in 1839

it would always be too nearly in the line joining the earth and sun, and too remote from the earth to admit of being seen.

Santini has announced its return to its perihelion, February 11th, 1846, under favourable circumstances. It is expected to be visible for a month or two before and after that date.

### COMETS SUPPOSED TO BE PERIODICAL.

Besides these comets of established period, there are several others supposed to be identical with former visitors.

The comets of 975, 1264, and 1556, are found to have similar elements, as far as we can judge from the imperfect accounts derived from the ancient chronicles. If they are the same, the period is about 291 or 292 years, and the comet should, in this case, return in 1847 or 1848. This is, however, quite doubtful.

The comet of 1680 was formerly supposed to have a period of 575 years. A very careful discussion of all the ancient observations, by Encke, is considered as conclusive against this supposition.

The comet of 1770 was found, by Lexell, to have a period of $5\frac{1}{2}$ years, yet it has never been seen since. La Place found that the action of Jupiter previous to the year 1770 had so completely changed the form of the orbit of this comet as to bring it into view in 1770, though it had been invisible before. After 1770, Jupiter produced a contrary effect, and caused it to revolve in an orbit

having its perihelion distance beyond Ceres, so that, perhaps, it will never again be visible.

The great comet of 1843, which is fresh in our recollections, strongly resembled in its appearance those of 1668 and 1689. It is also found that one set of elements, with a period of $21\frac{7}{8}$ years, will represent the paths in the heavens of the comets of these three dates. If they are the same, it will return again about the beginning of the year 1865.

Mr. Clausen of the Dorpat Observatory, Mr. Capocci of Naples, and the astronomers of the High-School Observatory, in Philadelphia, each, without the knowledge of the others, have expressed themselves in favour of this short period. Capocci has even thought it possible that it may return three times in that term.

Mr. Nicolai, of the Manheim Observatory, has examined the effect of a shortening of its period upon its elements for 1843, and concludes that it is perfectly consistent with all that is known of its path in the heavens on that occasion.

### THE THIRD COMET OF 1843.

This comet was discovered on the 25th of November, 1843, by M. H. Faye, of the Paris Observatory. It was re-discovered in this country on the 27th of December, by Mr. J. S. Hubbard, at the New-Haven Observatory. The parabolic elements of several astronomers being found unsatisfactory, M. Goldschmidt, of Gottingen, at the request of Gauss, computed, in December last, an orbit on the method of the latter, and found a

Great Comet of 1843.

period of $6\frac{2}{3}$ years. M. Faye, in January, computed an orbit on the same method, and found a period of $7\frac{1}{5}$ years. The astronomers of the Philadelphia High-School Observatory have computed an orbit on a similar plan, from a series of observations, including an interval of 61 days, and found a period of $6\frac{5}{6}$ years. The motion is direct, the inclination to the ecliptic is 11° 6′. The eccentricity is 0.52. The least distance is 162, and the greatest is 522 millions of miles from the sun.

This comet can never approach within 60 millions of miles of the earth; but its aphelion distance being a little greater than that of Jupiter, and occurring near the ascending node, when this event takes place while Jupiter is about entering the sign of the Scorpion, they may approach very near each other and remain so for the greater part of a year. This event occurred in the year 1840, at which time Jupiter's attraction for this comet was about a tenth part of the sun's, and must have produced a considerable alteration of its orbit.

This heavenly body seems to form a connecting link between the asteroids and the other comets. Hitherto there was a well-marked distinction between planets and comets. The eccentricity of the former was below *one quarter*, that of the latter above *three quarters*. This body, with an eccentricity of *one half*, holds a medium rank, and removes one of the most distinctive features. In the degree of nebulosity of the surfaces of planets and comets there is also a gradation. Mars is more nebulous than the other old planets except, perhaps, the earth. Ceres is surrounded by a still greater nebulosity. Next in degree of

nebulosity are this comet and those of Encke and Gambart.

The position of its orbit in the heavens is quite unstable; perhaps its present short period is owing to the action of Jupiter in 1839 and 1840. On some future occasion Jupiter may possibly cause it to move in such an orbit as to become invisible. Its fate would then resemble that of Lexel's comet.

## SEC. 23.

### ECLIPSES OF THE MOON.

Since the earth and the moon are opaque bodies, receiving their light from the sun, and being both much smaller than the sun, they must always carry with them a shadow of a conical form, the axis of which is a line drawn from the centre of the sun through the centre of the earth or moon. When the moon passes through the shadow of the earth it is wholly or partially deprived of the sun's light by the interposition of the earth: this phenomenon is called an *eclipse of the moon* or a *lunar eclipse;* it can only happen when the moon is in opposition, or at the time of full moon: if the moon always moved in the plane of the ecliptic, it would pass through the earth's shadow and be eclipsed every full moon. But, as has been already stated, the lunar orbit is inclined to the plane of the ecliptic, and only coincides with it in two points, called the nodes; and she will be eclipsed at the *full* moon only when that occurs near one of the nodes, at other times she will pass either above or below the shadow of the earth at the time of her full phase.

When the moon is at such a distance from the node, at the time of opposition, as to be only in part involved in the shadow, the eclipse is said to be *partial.* If the whole disc of the moon is obscured by the shadow, it is called a *total* eclipse.

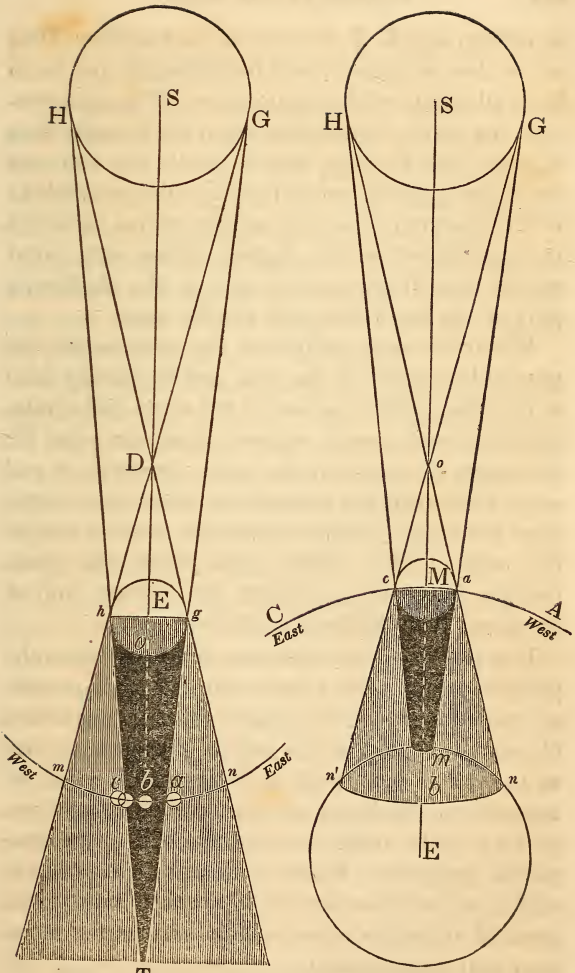
And when it is exactly in its node at the time of opposition, the centres of the sun, earth and moon all lie in the same straight line, and the moon's centre passes through the centre of the shadow; it is then said to be *centrally* eclipsed.

The conical shadow of the earth terminates in a point about $3\frac{1}{2}$ times the distance of the moon from the earth. The breadth of the shadow at the point where the moon passes through it is, on the average, about $2\frac{2}{3}$ times the moon's diameter.

The apparent diameter of the disc of the moon is divided into 12 equal parts, called *digits*. The greatest eclipse of the moon may amount to 22 digits; this is called the *quantity* of the eclipse.

The duration of a lunar eclipse depends partly upon its quantity, and partly upon the velocity of the moon's motion across the shadow, which is the same as her motion from the sun. This motion is swiftest when the moon is in her perigee; and the duration of a central eclipse will then be shortest, though the moon's diameter and that of the shadow, at the place where the moon passes through it, are greatest. The longest duration of a partial eclipse is about 2 hours 18 minutes, and that of a total eclipse 4 hours 38 minutes.

In Fig. 1, on the following plate, let S be the centre of the sun, E that of the earth, and *a*, *b* and *c*, the centre of the moon in its orbit, a portion of which is represented by the arc *m*, *n*. The space *g*, T, *h*, included between the tangent lines H, *h*, T, and G, *g*, T, will represent the shadow


H
S
G
D
E
h
g
West
m
c
b
a
n
East
T
H
S
G
o
c
M
a
C
A
East
West
n'
m'
b
n
E

or *umbra*, and E, T, the axis of the shadow. The entire disc of the sun will be hidden by the earth from all points within that space. The space behind the earth, included between the tangent lines H, *g*, *n*, and G, *h*, *m*, which touch the sun and earth on opposite sides, is called the *penumbra;* it is a frustrum of a cone, only a section of which is represented in the figure. From any point within this frustrum, but not in the shadow, a part of the sun's disc only can be seen.

When the moon arrives at the point *m*, she begins to lose sight of the sun, and in passing from *m* to *c* the visible portion of the sun's disc diminishes to a very small segment, near the point H; the moon, as seen from the earth, grows more and more faint until she reaches the shadow, at which time the eclipse begins upon the eastern side of the moon. The eclipse ends when the moon reaches the position *a*, where the western limb of the moon just touches the shadow.

It is impossible to determine by observation the precise instant when a lunar eclipse begins or ends, in consequence of the shade of the penumbra blending into that of the umbra in such a manner as to render it difficult to distinguish the line of separation. Eclipses of the moon are, therefore, of very little value for astronomical or geographical purposes. Every eclipse of the moon is visible at the same instant of absolute time, to all parts of the earth above whose horizon the moon is at that time situated.

## ECLIPSES OF THE SUN.

The moon, when in conjunction, if near one of her nodes, is interposed between the earth and the sun, and consequently hides the sun, either wholly or in part, from us: this phenomenon is called an *eclipse of the sun* or a *solar eclipse.*

These eclipses can only occur at the time of new moon, and not then, unless the moon is at or near one of her nodes, owing to the inclination of her orbit to the plane of the ecliptic.

In Fig. 2, S, M and E represent the centres of the Sun, Moon and Earth; the dark space between the lines *a m* and *c* $m^1$, represents a section of the moon's conical shadow which would terminate at *b* if it were not cut off by the surface of the earth at *m m'*. This shadow is surrounded, as is that of the earth, by a penumbra, of the form of a frustrum of a cone, represented by the lighter space between the lines *a n* and *c n'*.

As the moon moves in her orbit from A towards C, her penumbra moves over the earth's surface from west to east, passing in succession over different parts. At all places on the line traversed by the axis or centre of the shadow, the sun is *centrally* eclipsed; and at all places near this line over which the shadow passes the eclipse is *total;* and at all places traversed by the penumbra, but not by the shadow, only a part of the sun's disc is obscured by the moon, and the eclipse is *partial.* The magnitude of the partial eclipse is in propor-

tion to the nearness of the place to the shadow. At the points $n$ or $n'$ the moon appears only to touch the disc of the sun.

If the moon, at the time the sun is centrally eclipsed, is at such a distance from the earth that its shadow does not reach the surface of the latter, at all places on the line traversed by the axis of the cone, the edge of the sun appears as a bright ring surrounding the moon. This phenomenon is termed an *annular eclipse.*

If at the time of conjunction the moon is so far from her node that her shadow does not touch the earth, the sun is not totally eclipsed at any part of the earth's surface; but those places passed over by the penumbra experience a *partial eclipse.*

The greatest breadth of the path of the shadow of the moon over the earth's surface is about 170 miles. This occurs when the moon is in its perigee and the earth in its aphelion at the time of conjunction. When the moon is in its apogee and the earth in its perihelion at the time of conjunction, the eclipse, if there be one, is annular; the apparent diameter of the moon is then much less than that of the sun, and the breadth of the annulus or ring is the greatest possible. The greatest breadth of the path traversed by the moon's penumbra when it falls perpendicularly on the surface, is about 4830 miles. An eclipse of the sun is therefore visible only to a small portion of the inhabitants of the earth, who see it differently according to their different situations upon its sur-

face. The greatest breadth of that part of its surface at which an eclipse can be annular, is about 200 miles.

The longest possible time that a solar eclipse can continue total, at any place, is 8 minutes; and the longest time that an eclipse can continue annular, is 12 minutes.

When the moon at the time of conjunction is $19\frac{3}{4}°$ distant from her nearest node, there can be no eclipse; if the distance is less than $13\frac{1}{2}°$, there must be an eclipse for some part of the earth; and if its distance is between these limits, a further calculation is necessary to determine whether an eclipse will happen or not. For eclipses of the moon, these limits are much more narrow. An eclipse of the moon can never happen when she is, at the time of opposition, more than $13\frac{1}{3}°$ from her nearest node, and an eclipse is certain only when she is within $7\frac{3}{4}°$ of her node: between these limits the moon will sometimes be eclipsed, and at other times not.

There can never be more than seven, nor less than two eclipses in a year. When there are but two, both are of the sun; when there are seven, five of them are of the sun and two of the moon.

In a series of 223 lunar months, the eclipses occur nearly in the same order and magnitude. 223 synodic revolutions of the moon, and 19 synodic revolutions of her line of nodes, differ from each other only by about 0.46 of a day, so that at the end of this period the earth, the moon, the sun, and

the moon's nodes, are nearly in the same relative positions as at the beginning of it. This period is 18 Julian years and 11 days, and in general there will be in this space of time 70 eclipses, of which 29 are of the moon, and 41 are of the sun.

This period was known to the Chaldean astronomers, by whom it was called the *Saros*. It was used by them in predicting eclipses.

## SEC. 24.

### TIDES.

The ocean, which covers more than one-half of our globe, is in continual motion, rising and falling alternately without intermission. This elevation and depression is denominated the *tide*, and is occasioned by the influence of the sun and moon, more particularly of the latter. The rising of the tide is called *flood*, and its falling *ebb* tide. When the water has reached its greatest height, it is said to be *high tide;* and when after ebbing it has reached its least elevation, it is said to be *low tide.*

The surface of the ocean rises and falls twice in the course of a lunar day, or 24h. 50m. 48s. of mean solar time. The average interval between two successive high or low tides, is 12h. 25m. 24s.

There are also two kinds of tides, each of which occur twice in a lunar month: the *spring tides*

happen about the time of new and full moon, and are higher than the ordinary tides; the *neap tides* occur about the time of the first and last quarter of the moon, at which time the surface of the ocean at high tide is less elevated than at other times. The tides are also higher than usual about the vernal and autumnal equinoxes, and highest at the latter period.

The sea is observed to flow from the east towards the west for about six hours; then, after an apparent rest of about a quarter of an hour, it begins to ebb, or retire, for about the same time. The rivers, which had their motion reversed, resume their natural course; and, after another seeming pause of a quarter of an hour, the sea, which has now fallen to its lowest pitch, begins to rise again. Thus it continues to rise and fall alternately throughout the year; but with a difference in time of about 50 minutes every day, the same time that the moon varies in coming to the meridian of any given place.

The retardation in the time of high water, however, varies with the phases of the moon: it is least near the syzygies, when the tides are at their maximum, and greatest near the quadratures, when the tides are at their minimum. The variation in the distances of the sun and moon from the earth, and also their declination, have an effect on the retardation of the tides. When the moon has north declination, the tides are higher in northern latitudes when she passes the

meridian above the horizon, than when she passes below it: but when she has southern declination, the reverse of this takes place.

If the earth were at rest, and there were no influence from either sun or moon, the waters in the ocean would be truly spherical. On the other hand, if the earth and moon were without motion, and the earth covered all over with water, the attraction of the moon would raise the water in a heap in that part of the ocean to which the moon was vertical; and there probably it would always continue. But by the rotation of the earth upon its axis, each part of its surface to which the moon is vertical, is presented to the action of the moon; and thus are produced two floods and two ebbs in every rotation.

The particles of water under the moon are more attracted than the centre of gravity of the earth, in the inverse ratio of the square of the distances; hence they have a tendency to leave the earth, but are retained by their gravitation, which is diminished by this tendency. On the contrary, the moon attracts the centre of the earth more powerfully than she attracts the particles of water in the hemisphere opposite to her; so that the earth has a tendency to leave the waters, but is retained by gravitation, which is again diminished by this tendency. Thus the waters immediately under the moon are drawn from the earth at the same time that the earth is drawn from those which are diametrically opposite to her; in both instances producing an elevation of the ocean of nearly the same amount; for the diminution of the gravitation of the particles in each position is almost the same, on account of the distance of the moon being great in comparison with the earth's radius.

The distance of the moon from the centre of the earth is 60 times the radius of the latter; and hence her distance from the surface of the ocean immediately under her is $\frac{59}{60}$ of her distance from the centre. Now, since attraction varies inversely as the square of the distance, the moon's attraction for the particles of water under her is $\frac{3600}{3481}$ of her attraction for the centre of the earth, or the former is about $\frac{1}{30}$ greater than the latter; and on the contrary her attraction for the waters on the opposite side of the earth is nearly $\frac{1}{30}$ less than her attraction for the centre. Were the earth entirely covered by the sea, the water thus attracted by the moon would assume the form of an oblong spheroid, whose greater axis would point towards the moon, since the columns of water under the moon and in the direction diametrically opposite to her, are rendered lighter in consequence of the diminution of their gravitation; and in order to preserve the equilibrium, the axes 90° distant would be shortened. The elevation, on account of the smaller space to which it is confined, is twice as great as the depression, because the contents of the spheroid always remain the same. The effects of the sun's attraction are in all respects similar to those of the moon's, though less in degree, on account of its distance: he therefore only modifies the form of this spheroid a little.

If the waters were capable of assuming the form of equilibrium instantaneously—that is, the form of the spheroid—its summit would always point to the moon, notwithstanding the earth's rotation; but on account of their resistance, the rapid motion produced in them by rotation prevents them from assuming at every instant the form which the equilibrium of the forces acting on them requires. Hence, on account of the inertia of the waters, if the tides be considered relatively to the whole earth, and open sea, there is a meridian about 30° eastward of the moon, where it is always high water, both in the hemisphere where the moon is, and in that which is opposite. On the west side of this circle the tide is flowing, on the east side it is ebbing, and on every part of the

meridian 90° distant, it is low water. These tides must necessarily happen twice in a day, since the rotation of the earth brings the same point twice under the meridian of the moon in that time; once under the superior, and once under the inferior, meridian.

The mean force of the moon to move the waters of the ocean is to that of the sun as 5 to 2, nearly. Therefore, if the action of the sun alone produce a tide of two feet, that of the moon will be five feet. Hence, when the sun and moon act jointly on the tides, which is the case at the change and full of the moon, they are stronger and run higher than at other times, and constitute the *spring tides:* but when the sun and moon are 90 degrees apart, their attractive powers are opposed, and the tides are consequently weaker and lower; and these are the *neap tides.*

It has been already stated, that when the moon is in her quarter, the tides are at the lowest, because the influences of the sun and moon counteract each other; that is, they act in different directions; the attraction of the one raising the waters, while that of the other depresses them. The moon of herself would raise the waters five parts under her; but the sun, being then in a line with low water, would keep the tide from falling so low there by two parts, and consequently from rising so high under and opposite to the moon, so that the height of the waters in the latter places would be reduced to three parts.

The tides are known to rise higher at some

seasons than others; which may be accounted for on the principle of the moon moving round the earth in an elliptic orbit, which brings her nearer to the earth at one time than at another. When she is nearest, her attraction is the strongest, and consequently it raises the tides most; and when she is farthest from the earth, the tides are lowest, because her attraction is the least.

But for what has been said, it might be supposed that the tides are highest when the moon is on the meridian, or due north or south. But however just the theory, this is not the case experimentally. In open seas, as remarked above, where the water flows freely, the moon has generally passed the meridian about two hours when it is high water. This is owing to the impetus given to the waters: for even were the moon's attractions to cease upon her arrival at the meridian, the motion of ascent given to the water would make it continue to rise for some time after; and much more must it do so when the attraction is not withdrawn, but only diminished; as a little impulse given to a moving ball will cause it to move still farther than it otherwise would have done.

The tides also answer not always to the same distance of the moon from the meridian, at the same place; but are variously affected by the action of the sun, which brings them on sooner when the moon is in her first and third quarters, and keeps them back later when she is in her second

and fourth. In the former case, the tide raised by the sun alone would be earlier than the tide raised by the moon; and in the latter case, later.

The greatest spring tide will happen when the moon is in perigee, if other things be the same; and the succeeding spring tide, when the moon is in apogee, will be the least. But as the effect of a luminary is greater the nearer it approaches the plane of the equator, and as the earth is nearer the sun in winter than in summer, and still nearer in February and October than in March and September, the greatest tides happen not till some time after the autumnal equinox, and return a little before the vernal.

Although the highest tides are produced by the conjunction and opposition of the sun and moon, their effects are not *immediate;* but, from the continuation of motion, are greatest and least some time after their forces have ceased to co-operate. Hence the highest spring tides generally occur 36 hours after the new and full moons, and the lowest neap tides 36 hours after the first and third quadratures.

In places remote from the equator, the two immediately succeeding tides are unequal whenever the moon declines from the equator; the evening tides in summer exceeding the morning tides, and the contrary in winter. For if the greatest elevation immediately under the moon point to one side of the equator, the opposite greatest elevation will point as much to the other side; and those

places which are on the same side of the equator with the luminary approach nearer to the greatest elevation when she is above the horizon, than to the greatest opposite elevation when she is below it. This inequality is greatest when the sun and moon have the same declination, and also in places most remote from the equator. The nearer the place approaches the pole, the farther is it removed from the greatest elevation on the opposite side of the equator; and the less tide, continually diminishing as the place approaches the pole, is at length lost altogether, so that only one tide occurs in the day.

In open seas, the tides do not rise to very great heights, compared with what they do in wide-mouthed rivers, opening in the direction of the stream of the tide; for. in channels growing gradually narrower, the water is accumulated by the contracting banks. The general elevation in the open sea is about 11 feet for spring tides, and 7 feet for neap tides: yet at London the spring tides rise 19 feet; at the mouth of the Indus they are full 30 feet; at St. Maloes, in France, 45 feet; and at Cumberland, at the head of the Bay of Fundy, no less than 71 feet. This last is the highest in the world.

Though the tides in open seas are at the highest about two hours after the moon has passed the meridian, yet the waters in their passage through shoals and channels, and by striking against capes and head-lands, are so retarded, that, to different

places, the tides happen at all distances of the moon from the meridian. Other impediments to the course of the waters arise from the shallowness of the seas in some places, the intervention of continents, islands, and straits between them, &c.; all which cause exceptions to the general rules here laid down; but these can only be explained from particular observations on the nature of the tides at particular places.

Lakes have no tides, because they are generally so small that when the moon is vertical she attracts every part of them alike, and by rendering all their waters equally light, no portion of them can be raised higher than the rest. The Mediterranean and Baltic Seas have very trifling elevations, because the inlets by which they communicate with the ocean are so narrow, that they cannot, in the short interval of the oceanic tides, receive or discharge enough sensibly to raise or sink their surfaces.

Lines drawn through all the adjacent parts of a tract of water which have high water at the same time, are called *co-tidal* lines.

The *unit of altitude* for a particular place, is the height of the maximum tide after the syzygies, being usually about 36 hours after the full moon. This is ascertained by measurement. For instance, its value for several places has been found as follows:

| | |
|---|---|
| Cumberland, Bay of Fundy | 71 feet. |
| Boston | 11 " |
| New Haven | 8 " |
| New York | 5 " |
| Charleston, S. C. | 6 " |

The *establishment* of any port is the mean interval between noon and the time of high water on the day of new or full moon. When this is known, it may be used in computing the time of high water throughout the year.

The great height of the tides in the Bay of Fundy is attributed to the meeting of the great northern and southern tide waves of the Atlantic, which here come together in opposite directions.

*Atmospheric tides* undoubtedly occur, but they are too small and delicate in their nature to affect the barometer sensibly.

# APPENDIX.

## MÆDLER'S ELEMENTS OF THE ORBITS OF THE PRINCIPAL STELLAR SYSTEMS, OR BINARY STARS.

| Stellar System. | Period in years. | Time of perihelion passage. | Mean yearly Motion. | Ascending Node. | Inclination. |
|---|---|---|---|---|---|
| p Ophiuchi.... | 92.870 | 1812.73 | —232.58′ | 126° 55′ | 64° 51′ |
| 3062 Struve... | 94.765 | 1837.41 | +227.93 | 15 3 | 35 31 |
| γ Virginis .... | 145.409 | 1836.31 | —148.45 | 60 38 | 24 39 |
| ζ Cancri..... | 58.910 | 1853.37 | —366.66 | 1 28 | 63 17 |
| ζ Herculis.... | 31.468 | 1829.50 | —730.45 | 39 26 | 50 53 |
| η Coronæ..... | 43.246 | 1815.23 | +499.47 | 24 18 | 71 8 |
| σ Coronæ..... | 608.450 | 1826.60 | + 35.50 | 25 7 | 29 29 |
| ω Leonis..... | 82.533 | 1849.76 | +261.72 | 135 11 | 46 33 |
| ξ Ursæ Majoris | 60.460 | 1816.95 | —357.26 | 95 0 | 52 15 |
| α Geminorum.. | 232.124 | 1913.9 | — 93.05 | 23 5 | 70 58 |
| λ Ophiuchi ... | 88. | 1798. | +245. | 184 | 45°–50° |

| Stellar System. | Perihelion from Node. | Eccentricity. | Semi axis Major. | Cube root of mass × by parallax. |
|---|---|---|---|---|
| p Ophiuchi..... | 142° 53′ | 0.4438 | 4.192″ | 0.2044″ |
| 3062 Struve..... | 135 27 | 0.4496 | 1.255 | 0.0604 |
| γ Virginis..... | 78 22 | 0.8682 | 3.402 | 0.1230 |
| ζ Cancri..... | 266 0 | 0.2349 | 1.292 | 0.0851 |
| ζ Herculis..... | 262 4 | 0.4545 | 1.189 | 0.1193 |
| η Coronæ..... | 261 21 | 0.3376 | 1.088 | 0.0883 |
| σ Coronæ..... | 64 28 | 0.6998 | 3.918 | 0.0546 |
| ω Leonis..... | 185 27 | 0.6434 | 0.857 | 0.0452 |
| ξ Ursæ Majoris... | 129 41 | 0.4037 | 2.290 | 0.1487 |
| α Geminorum.... | 87 37 | 0.7972 | 7.008 | 0.1860 |
| λ Ophiuchi..... | 0 | 0.37 | 1.1 | 0.05 |

## STRUVE'S LIST OF DOUBLE AND MULTIPLE STARS, WHICH, FROM THEIR RELATIVE MOTIONS, ARE CONSIDERED AS PHYSICALLY CONNECTED TOGETHER, OR COMPOSING STELLAR SYSTEMS.

### CLASS I.—DISTANCE OF THE COMPONENTS FROM 0″ TO 1″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| 36 Andromeda. | 7 Tauri. | 460 Struve Ceph. |
| ω Leonis. | Atlas Pleiad. | 1500 Struve. |
| γ Virginis. | ε Equulei. | 287 Piazzi XVIII. |
| 42 Comæ Beren. | 2384 Struve. | |
| 1819 Struve. | | |
| η Coronæ. | | |
| γ Coronæ. | | |
| λ Ophiuchi. | | |
| ζ Herculis. | | |
| 2173 Struve. | | |
| τ Ophiuchi. | | |
| 4 Aquarii. | | |
| 3062 Struve | | |

### CLASS II.—DISTANCE FROM 1″ TO 2″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| 12 Lyncis. | ι Cassiopeiæ. | 1338 Struve Lyncis. |
| ζ Cancri. | 314 Struve Persei. | 1867 Struve Bootis |
| 1037 Struve. | 32 Orionis. | 73 Ophiuchi. |
| ξ Ursæ Majoris. | 170 Piazzi VII. | 429 Piazzi XX. |
| 74 Piazzi XV. | 1768 Struve Can. | 185 Struve. |
| ξ Libræ. | 93 Piazzi II. | |
| σ Coronæ. | | |
| 2107 Struve Herc. | | |
| δ Cygni. | | |
| 127 Piazzi XIII. | | |

CLASS III.—DISTANCE FROM 2″ TO 4″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| ε Hydræ. | γ Ceti. | 425 Struve. |
| γ Leonis. | 301 Piazzi VI. | 258 Piazzi IV. |
| ι Leonis. | 81 Virginis. | 742 Struve Tauri. |
| ε Bootis. | ϱ Herculis. | ζ Orionis. |
| 44 Bootis. | 49 Cygni. | 84 Virginis. |
| δ Serpentis. | | 39 Bootis. |
| 49 Serpentis. | | 39 Draconis. |
| μ Draconis. | | ε Draconis. |
| ε Lyræ. | | ψ Cygni. |
| 5 Lyræ. | | 26 Piazzi XX. |
| ζ Aquarii. | | 15 Monocerotis. |
| 2120 Struve Herc. | | 2309 Struve. |

CLASS IV.—DISTANCE FROM 4″ TO 8″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| Castor. | 38 Geminorum. | 41 Aurigæ. |
| ζ Cancri. | ζ Coronæ. | 1083 Struve. |
| 1263 Struve. | 1985 Struve. | 1121 Struve Offici. |
| $\sigma^2$ Ursæ Majoris. | 2725 Struve. | $v^1$ Cancri. |
| ξ Bootis. | μ Cygni. | 1311 Struve Cancri. |
| ξ Libræ. | 546 Struve. | 21 Ursæ Majoris. |
| p Ophiuchi. | 1804 Struve Bootis. | 1813 Struve. |
| | 2776 Struve. | 2917 Struve. |
| | 3024 Struve. | 39 Eridani. |
| | | 583 Struve. |
| | | 625 Struve. |
| | | 1690 Struve. |
| | | 2263 Struve. |
| | | 2429 Struve. |

## Class. V. & VI.—distance from 8″ to 16″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| $\eta$ Cassiopeiæ. | 14 Aurigæ. | 570 Struve. |
| 1516 Struve. | $\iota$ Orionis. | 55 Eridani. |
| 61 Cygni. | $\varkappa$ Bootis. | 26 Aurigæ. |
| 2760 Struve. | $\varepsilon$ Equulei. | 19 Lyncis. |
| 23 Struve. | 248 Piazzi XXI. | 177 Piazzi XX. |
| 86 Struve. | 209 Piazzi XXII. | $\beta$ Cephei. |
| 2708 Struve. | 288 Struve. | 2848 Struve. |
| | $\iota$ Leporis. | 221 Struve. |
| | $\zeta$ Sagittæ. | $\theta$ Persei. |
| | | 563 Struve. |
| | | 719 Struve. |
| | | 1882 Struve Draco. |
| | | 2051 Struve. |
| | | 396 Piazzi XIX. |

## Class VII. & VIII.—distance from 16″ to 32″.

| Certain. | Probable. | Suspected. |
|---|---|---|
| 100 Piscium. | 83 Leonis. | $\zeta$ Piscium. |
| 1321 Struve. | $\varkappa$ Herculis. | $\iota$ Cancri. |
| $o$ Draconis. | $\chi$ Cygni. | 1283 Struve. |
| $\delta$ Herculis. | 248 Piazzi XXI. | 1575 Struve. |
| 251 Piazzi O. | 1132 Struve. | $\pi^1$ Ursæ Minoris. |
| 125 Struve. | 1616 Struve. | 2063 Struve. |
| 142 Struve. | | 2703 Struve. |
| 447 Struve. | | 51 Piscium. |
| $\delta$ Equulei. | | 26 Ceti. |
| | | 101 Struve. |
| | | 545 Struve. |
| | | 549 Struve. |
| | | $h$ Ursæ Majoris. |
| | | 44 Virginis. |
| | | 2115 Struve Herc. |
| | | 250 Piazzi XIX. |
| | | 16 Lacertæ. |
| | | 3039 Struve. |

STRUVE'S CATALOGUE OF STARS, WHICH, FROM THEIR PROPER MOTIONS, ARE CONSIDERED TO BE PHYSICALLY DOUBLE, OR STELLAR SYSTEMS.

| Name of Stellar System. | Distance of Components. | Annual proper motion. |
|---|---|---|
| 61 Cygni | 16.0″ | 517″ |
| $\eta$ Cassiopeiæ | 9.5 | 119 |
| p Ophiuchi | 6.1 | 112 |
| 83 Leonis | 29.6 | 82 |
| $\mu$ Herculis | 29.9 | 80 |
| $\xi$ Ursæ Majoris | 1.8 | 74 |
| $\zeta$ Herculis | 1.1 | 55 |
| 5 Serpentis | 10.1 | 54 |
| $\gamma$ Virginis | 2.0 | 52 |
| 42 Comæ Berenicis | 0.0 | 45 |
| 49 Serpentis | 3.2 | 43 |
| $\chi$ Cygni | 25.8 | 43 |
| 44 Bootis | 3.3 | 41 |
| 66 Ceti | 15.5 | 40 |
| $\theta$ Persei | 15.4 | 37 |
| 9 Piazzi XI | 1.1 | 36 |
| 219 Piazzi XXII | 4.1 | 36 |
| 88 Leonis | 15.3 | 34 |
| $\mu$ Cygni | 5.6 | 34 |
| 84 Virginis | 3.4 | 33 |
| 33 Pegasi | 2.5 | 32 |
| $\gamma$ Leonis | 2.5 | 31 |
| $\sigma$ Coronæ | 1.3 | 31 |
| 94 Aquarii | 13.4 | 29 |
| $\psi$ Draconis | 30.9 | 27 |
| 12 Canum | 19.9 | 24 |
| $\eta$ Coronæ | 0.7 | 22 |
| 17 Virginis | 19.3 | 21 |
| $\gamma$ Ceti | 2.6 | 21 |
| $\zeta$ Piscium | 23.5 | 19 |
| Castor | 4.7 | 19 |
| 98 Piazzi III | 6.1 | 18 |
| $\zeta$ Ursæ Majoris | 14.4 | 16 |
| $\sigma^2$ Ursæ Majoris | 4.6 | 13 |
| $\gamma$ Coronæ | 0.0 | 11 |
| $\theta$ Serpentis | 21.6 | 11 |
| 38 Piscium | 4.7 | 11 |
| 5 Lyræ | 2.6 | 9 |
| $\varepsilon$ Lyræ | 3.0 | 7 |

## GENERAL TABLES

### OF THE

# PRIMARY PLANETS.

| | Mean Distance from the Sun, or Semi-Axis. | Sidereal Revolution in Mean Solar Days. | Eccentricity in parts of the Semi-Axis. |
|---|---|---|---|
| Mercury | 0.3870938 | 87.96928 | 0.2056163 |
| Venus | 0.7233317 | 224.70078 | 0.00686182 |
| Earth | 1.0000000 | 365.25637 | 0.01679226 |
| Mars | 1.523691 | 686.97964 | 0.0932168 |
| Vesta | 2.36148 | 1325.485 | 0.088560 |
| Juno | 2.66946 | 1593.067 | 0.255560 |
| Ceres | 2.77091 | 1684.735 | 0.0767378 |
| Pallas | 2.77263 | 1686.305 | 0.241998 |
| Jupiter | 5.202767 | 4332.58480 | 0.0481621 |
| Saturn | 9.538850 | 10759.21981 | 0.0561505 |
| Uranus | 19.18239 | 30686.82055 | 0.0466108 |

| | Mean Longitude. | Mean daily Motion in Longitude. | Longitude of the Perihelion. |
|---|---|---|---|
| Mercury | 112° 16′ 4.8″ | 4° 5′ 32.6″ | 74° 20′ 5.8″ |
| Venus | 146 44 55.8 | 1 36 7.8 | 123 43 6. |
| Earth | 100 53 29.9 | 59 8.3 | 99 30 28.6 |
| Mars | 233 5 33.9 | 31 26.7 | 332 22 51.2 |
| Vesta | 84 47 3.2 | 16 17.9 | 249 11 37. |
| Juno | 74 39 43.6 | 13 33.7 | 54 17 12.7 |
| Ceres | 307 3 25.6 | 12 49.4 | 147 41 23.5 |
| Pallas | 290 38 11.8 | 12 48.7 | 121 5 0.5 |
| Jupiter | 81 54 48.6 | 4 59.3 | 11 7 38. |
| Saturn | 123 6 29.3 | 2 0.6 | 89 8 20. |
| Uranus | 173 30 37.2 | 42.4 | 167 30 24. |

| | Inclination to the Ecliptic. | Longitude of the Ascending Node. | Greatest Equation of the Centre. |
|---|---|---|---|
| Mercury | 7 0 5.9 | 45 57 9. | 23 40 43.0 |
| Venus | 3 23 28.5 | 74 51 41. | 47 10.8 |
| Earth | 0 0 0 | 0 0 0. | 1 55 27.6 |
| Mars | 1 51 6.2 | 47 59 38. | 10 41 33.3 |
| Vesta | 7 7 57.3 | 103 20 28.0 | 10 9 26.7 |
| Juno | 13 2 10.0 | 170 52 34.5 | 29 30 42.4 |
| Ceres | 10 36 55.7 | 80 53 49.7 | 8 47 58.2 |
| Pallas | 34 35 49.1 | 172 38 29.8 | 27 55 22.2 |
| Jupiter | 1 18 51.6 | 98 25 45. | 5 31 13.6 |
| Saturn | 2 29 35.9 | 111 56 7. | 6 26 12.1 |
| Uranus | 0 46 28.0 | 72 59 21. | 5 20 32.8 |

| | Mean Diameter. | Volume. | Mass. |
|---|---|---|---|
| Mercury | 0.391 | 0.060 | 2055 |
| Venus | 0.985 | 0.957 | 24886 |
| Earth | 1.000 | 1.000 | 27812 |
| Mars | 0.519 | 0.140 | 3731 |
| Jupiter | 11.225 | 1414.2 | 9541984 |
| Saturn | 9.022 | 734.8 | 2855511 |
| Uranus | 4.344 | 82.0 | 401526 |
| Sun | 112.060 | 1407124.0 | 1000000000 |
| Moon | 0.264 | 0.018 | 321 |

| | Density. | Force of Gravity. | Intensity of Light. |
|---|---|---|---|
| Mercury | 2.94 | 1.15 | 6.67 |
| Venus | 0.923 | 0.91 | 1.91 |
| Earth | 1.000 | 1.00 | 1.00 |
| Mars | 0.948 | 0.50 | 0.43 |
| Jupiter | 0.238 | 2.45 | 0.037 |
| Saturn | 0.138 | 1.09 | 0.011 |
| Uranus | 0.242 | 1.05 | 0.003 |
| Sun | 0.252 | 28.36 | —— |
| Moon | 0.619 | 0.163 | 1.00 |

NOTE. — In the above Tables the Elements of the Orbits of Vesta, Juno, Ceres and Pallas, are for 1831, July 23d. 0h., Mean Berlin Time. The others are for 1800, January 1st, 0h., Mean Paris Time.

# QUESTIONS TO PART I.

## Sec. 1.

### GENERAL DESCRIPTION OF THE HEAVENS.

What is the form of the surface of the heavens as it appears on a clear evening? By what does this surface appear to be bounded? What is the line called in which this plane intersects the heavens? What bodies appear to move in this hollow surface? And in what direction?

Describe the course pursued by a star which rises in the south-east. Where does it set? What of the path of a star which rises farther from the south point of the horizon?

What is the Zenith? What is the Meridian, and to what does it correspond? How does it divide the paths or arcs described by the stars while above the horizon? Are these arcs parallel or inclined to each other?

What portion of a circle is described by the stars in different parts of the heavens? By one which rises near the north point of the horizon? Are there any stars which never set? What is their apparent course? What are they called? What is the star called about which they appear to revolve? What is the North Pole of the heavens?

How do these motions, &c., correspond when observed on different evenings?

Describe the general appearance of the heavens as viewed from the earth. What is this motion called? What bodies appear to be fixed, and what bodies to move in the surface of the celestial sphere? How might the apparent diurnal motion of the heavens be accounted for?

## Sec. 2.

### PRELIMINARY DEFINITIONS.

What is the *Axis of the Heavens?* What are the North and South Poles?

What is the *Celestial Equator?* How does it intersect the horizon?

What are the Geometric Poles of the Equator? What is a *Great Circle?* What are the *Poles* of any circle? The Poles of a great circle?

How is every circle divided? How are Degrees, Minutes and Seconds marked? Illustrate the use of these symbols by an example.

What is a *Declination Circle?* What are these circles sometimes called?

What are *Parallels of Declination?*

What is a *Vertical Line?*

What are the *Zenith* and *Nadir* of any place?

What is the *Meridian* of a place? Where does it cut the horizon?

What is a *Vertical Circle?* The *Prime Vertical?*

What is the *Ecliptic?* The *Obliquity of the Ecliptic?* The *Equinoxes?* When does the Sun pass them? How are they named? Where are the Poles of the Ecliptic?

What is the *Equinoctial Colure?*

Define *Right Ascension.* How does it compare with the longitude of a place on the earth's surface? How is it sometimes estimated? How many degrees make an hour?

What is the *Declination* of a heavenly body? When is it North and when South? What Declination have bodies on the Equator? To what is Declination analogous?

How are Right Ascension and Declination designated?

## Sec. 3.

### CONSTELLATIONS.

How were the heavens divided by the early astronomers? What kind of names were given to the Constellations? What is said of their antiquity?

How are the Constellations bounded on the maps? What are works of this kind sometimes called? What is the correct title?

How are the stars in each Constellation distinguished? Give an illustration. Mention some of the particular names of stars.

Repeat the Greek Alphabet. Write the letters.

By whom were these letters assigned to the stars? Do they perfectly conform with the classification of the stars in the order of their brightness? What does this show?

## Sec. 4.

### MAGNITUDES OF THE STARS.

What can you say of the *Magnitudes* of stars? The *First* Magnitude? The *Second?* The *Sixth?* How is this classification extended to the telescopic stars?

How many Classes of telescopic stars does Sir John Herschel use? Of what magnitude are the smallest according to his classification? What is Struve's Classification? Which Magnitudes are used in this book?

## Sec. 5.

### A MORE PARTICULAR DESCRIPTION OF THE STARRY HEAVENS.

Give an account of the appearance of the starry heavens on a clear evening. What causes the stars to *twinkle*? Do they all twinkle? What are those which do not called? Why? Why are the others called *Fixed* stars? Into what classes are the fixed stars divided? How numerous do they appear to be? Are they so in reality? What is the actual number visible at any time? How many are there in the whole heavens in the first six classes? How is the illusion of the apparent countlessness of the stars explained? Have the stars all been counted? What else has been determined about them? What is required for obtaining a knowledge of the *Stars?* What for a knowledge of the *Earth?*

What of the number of stars revealed to us by the telescope? How do the six telescopic Classes compare with the first six?

How many stars of the sixth would it take to make one as bright as a star of the first magnitude? How many of the twelfth magnitude must be grouped together to produce the same degree of brilliancy?

If all the stars were of the same size, what should be the distance of those of the sixth, and what the distance of those of the twelfth magnitude, compared with those of the first? If they were, besides, situated at uniform distances in space, what conclusion might be formed respecting their numbers? How many are there of the first class? Of the second? Of the third? Of the fourth?

What is the probable number of the fifth magnitude? Of the sixth?

How many might we expect to find in the several telescopic classes?

How is this confirmed by observation? How many more might we expect a telescope, more powerful than any heretofore used, to reveal to us?

What can you say of the groups in which the stars present themselves?

## Sec. 6.

### OF THE DOUBLE AND MULTIPLE STARS.

What of the tendency to the formation of groups, as displayed on a close examination with the aid of a telescope?

What was Mitchel's opinion with regard to these double stars? What was the result of the observations of the elder Herschel? What brilliant discovery did he make? How has this since been confirmed? What discovery was afterwards made by Sir William Herschel? What of Struve's works on double stars? What was done by Sir J. F. W. Herschel? What of Encke's method?

How many pairs and multiples of stars are there within 32″ of each other? To what must this great prevalence of double and multiple stars be owing? By what name are these distinguished? What are the systems composed of two, three, &c., stars called? What other class of double stars is there? How are these named?

Do the *Binary* stars revolve around each other? When are two stars said to revolve around each other?

By what force are the *physically* double stars acted upon? What comparison is made between these and our solar system?

If we suppose an average to prevail in the size and brilliancy of the stars and in their distances apart, how many should we expect to find optically double in the first eight magnitudes? What is the actual number of double stars in these classes? How many of these should, by average, be optically double? What of the remainder? What are the indications of this connexion?

Of the triple and multiple stars, how many are supposed to form physical systems? At what does Mædler estimate the number of *binary* and *ternary* stars?

## Sec. 7.

### COMETS.

What is here said of Comets?

## Sec. 8.

### VARIABLE STARS.

What are *Variable Stars?*

Describe the star *o* Ceti. What is its period? What was its time of greatest brilliancy in 1844? How does its increase of light compare with its decrease?

Describe *Algol.* What of its vicissitudes of light? What is its colour? What is that of the other variable stars?

What is its period? Who discovered this star to be variable?

What can you say of the variable star in the Lion?

What of that in the Virgin?

Who discovered the variableness of the star in the Crown? What is the peculiarity of this star?

What can you say of *Ras Algethi?*

Mention some other variable stars.

What is the prevailing colour of variable stars? Which phase of light lasts longest? What star forms an exception to these rules?

What causes have been assigned for this remarkable variation of light?

What circumstance induced Hipparchus to make the first catalogue of stars? Give an account of the star which appeared in A. D. 389. What of the new star seen in the ninth century? Give a description of the one discovered by Tycho Brahe. What other new stars can you mention?

Is it probable that any stars have disappeared? How did Newton account for this?

## Sec. 9.

### NEBULÆ AND CLUSTERS OF STARS.

Mention some of the most remarkable clusters of stars. In what does the Milky-Way abound? What are these portions?

What can you say of the number of stars in some of these spots? What was Herschel's idea in reference to the position of our sun?

Give an account of the probable character of the Milky-Way. To what class of nebulæ may it belong? What must then be the position of our system to enable us to see it as we do? Why?

What does the nebulous region of the heavens embrace? Where is the most nebulous part of this zone?

What are *Resolvable Nebulæ?* What of the number of stars contained by some of them?

How great is the distance of these clusters? What of the irregular clusters? How were these regarded by Sir William Herschel?

Are all the objects of this class resolvable into stars? Why?

What are *Irresolvable Nebulæ?* Describe them more particularly. What are the most remarkable examples of this class? Describe them. Describe the annular nebula in Lyra.

Describe the *Planetary Nebulæ.* What of their dimensions?

What is the fourth class? Describe them. What are *Nebulous Stars?* Mention some examples.

Describe the Zodiacal Light. In what list of stars does this seem to place our sun? What of the variety of forms of the stellar nebulæ and nebulous stars?

What of the distribution of the nebulæ over the heavens? What analogy is there between the double and multiple nebulæ and the binary and multiple stars?

What is the number of nebulæ at present known? What are Mrs. Somerville's views in regard to this nebulous matter?

## Sec. 10.

### DESCRIPTION OF THE MAPS.

Give a general description of the first two Maps.

What do the next five represent?

Describe the eighth and ninth.

What of the next five?

What is the use of the fifteenth?

## Sec. 11.

### DESCRIPTION OF THE CONSTELLATIONS.

### Plate III.

Name the Constellations in Plate III.

Describe Ursa Minor. What of the magnitudes of the stars in it? Tell the names of the principal stars. Describe the Pole Star. Give the history of this constellation.

Where is Cepheus situated? How may it be known? What are the names of its principal stars? Give its history.

What is the situation of the Dragon? Where is the Pole of the Ecliptic? What of the magnitudes of the stars of this con-

stellation? Of what does the head consist? How many coils are there between the head and tail, and what of them? What stars are near the tail? For what is the star $\alpha$ remarkable? Mention the proper names of the principal stars. What is the fabulous history of this constellation?

By whom was the constellation of the Lizard formed?

What of Honores Frederici?

Who established the constellation of the Grey-Hounds? What names have been given to the two Hounds? What of the star $\alpha$?

What can you say of the constellation of the Mural Quadrant?

How may the Swan be known? Where does it lie? In what is it very rich? Give the names of the principal stars. Where is the double star "61 Cygni" situated? Describe it. For what will it be forever memorable? What is their distance from the earth? In what time does their light reach us? Is this supposed to be the nearest star? To what do the brightest probably owe, in a great measure, their great brilliancy? What great discoveries have resulted from researches after the parallax of the fixed stars? What is the history of this constellation?

## Plate IV.

Name the Constellations in Plate IV.

What are the names of the principal stars in the Great Bear? What is the Great Dipper, or *Charles' Wain*? Which are the *Pointers*? How can the right hinder leg be found? The left hinder foot? The right fore-foot?

Who instituted the constellation Custos Messium? Where does it lie?

When and by whom was Camelopardalis instituted? What does it contain?

Where is Cassiopeia? What are the principal stars? Which is the brightest of these? How can the position of the North Pole be determined by it? What remarkable discovery did Tycho Brahe make in this constellation? What is said of the star $\mu$? Relate the fabulous history of this constellation?

What of the Little Lion, its situation, &c.

By whom was the Lynx instituted?

Where is Perseus situated? What are the principal stars? How may *Algenib* be recognized? How *Algol*? For what is Algol remarkable? Describe it? Give the history of Perseus and Medusa's Head.

By whom, and in memory of what, was the Reindeer established? Where is it situated?

Where is Herschel's Telescope situated?

## Plate V.

Name the Constellations in Plate V.

How may Pegasus be known? What are the principal stars? How may $\varepsilon$ in the nose be found? How $\eta$? Relate the fable of Pegasus.

Where does the constellation Andromeda lie? What are the three principal stars? How are they situated? Mention some of the other stars with their situations. What four stars form nearly a square? Relate the fable.

Where is the constellation of the Triangles? What is the principal star?

How is the Fly situated? Of what is it composed?

How are the Fishes connected? Where are they situated? Relate the fable. When does the sun enter this sign?

How is Aries, or the Ram, recognized? What are the principal stars? What is its fabulous history? When does the sun enter this sign? What does this entrance constitute? What occurs at the poles at this time? What of the days and nights at this period? What is the position of the sun at this time?

## Plate VI.

Name the Constellations in Plate VI.

What are the two principal stars in Auriga? How may this constellation be easily recognized? What other small triangle is there? What is the history of the Charioteer?

Name the most remarkable stars in the Bull. Where is $\alpha$ and what is it sometimes called? How may it be known? Where are $\beta$, $\gamma$ and $\varepsilon$? Describe the cluster called the Hyades? What other remarkable group of stars is there in this constellation? How large a space does it occupy? How many stars does it contain? What are the names of the principal stars? How many of them are visible to the naked eye? Relate the fable of Taurus. That of the Pleiades. That of the Hyades. When does the sun enter Taurus?

What are the principal stars in the Crab? Where is Præsepe or the Manger? Describe it. Give the fabulous history of this constellation? When does the sun enter Cancer?

Which is the most beautiful constellation in the heavens? What of the antiquity of Orion? Name the principal stars. How are $\alpha$, $\beta$ and $\gamma$ situated? How $\delta$, $\varepsilon$ and $\zeta$? What do they form? What do $\kappa$, $\alpha$, $\gamma$ and $\beta$ form? How is the sword formed? What stars are in the shield? Where is the star $\sigma$, and what is said of it? Where is the great nebula? Describe it. What change does it appear to be undergoing? In what does this con-

stellation abound? What is the peculiarity of these nebulous stars? How does Herschel account for their variations? What is the history of Orion?

How is the constellation of the Twins distinguished? Where are $\gamma$, $\zeta$ and $\delta$? Where is the star $\mu$ situated? Relate the fable of Castor and Pollux. When does the sun enter this sign?

By whom was the Unicorn introduced? Where does it lie?

How is the Little Dog distinguished? What kind of a triangle does Procyon form with $\beta$ and $\gamma$ of the Twins? What is the history of this constellation?

## Plate VII.

What Constellations are represented in Plate VII.?

Where is Boötes situated? What are its principal stars? How may Arcturus be found? Where are the stars $\eta$ and $\xi$? Where are $\gamma$, $\beta$ and $\delta$? What figure do they form? Where is $\varepsilon$? Relate the history of this constellation?

What can you say of Lyra? What of Vega? What are the other principal stars? Where is this constellation situated? What stars in it form an equilateral triangle? Relate the fable of the Lyre.

What are the principal stars in the constellation Hercules? Where are they situated? In what line are $\alpha$, $\delta$ and $\pi$? What are the situations of $\zeta$, $\delta$, $\pi$ and $\varepsilon$? Where is $\beta$? What are the magnitudes of these stars? What interesting relation is there between our system and this constellation? Who first conceived the idea of this motion? Towards what point is our system ascertained to be moving? With what velocity? Give the history of Hercules and the Cerberus.

Where is the Northern Crown situated? What are its two principal stars? How may it be recognized? What is its history?

Where is the Polish Bull? What of it?

## Plate VIII.

Name the Constellations in Plate VIII.

What are the names of the principal stars in the Great Lion? How may Regulus and $\gamma$ be found? What stars form a curve on the neck? What constitute the Sickle? Where is Denebola? Tell how the other stars may be found. What is this sign supposed by the fabulists to be? When does the sun enter it?

What are the principal stars in the Virgin? What can you say of Spica? What do Spica, Arcturus and Denebola form? Tell how the other stars are pointed out. How is the head

marked? Give an account of the stellar system of Virginis. Explain the drawing of its orbit. What else can you say of this pair of stars? Relate the fable of the Virgin. When does the sun enter this sign?

Describe Coma Berenices. What is its appearance to the naked eye? Describe the pair of stars represented in the cut. What is the fabulous history of Berenice's Lock?

Where is the Sextant situated? By whom was it instituted?

## Plate IX.

Name the Constellations of Plate IX.

Who instituted the constellation Antinoüs? What stars does it contain? How may they be found?

Where is the Eagle situated? What are its principal stars? How may it be found?

Where do the Scales lie? Name the principal stars. How may $\alpha$ be found? Where is $\beta$? With what stars does it form a nearly equilateral triangle? What is the history of this sign? When does the sun enter it? What then occurs?

What are the principal stars in the Serpent-Bearer? Explain the method of finding the stars of this constellation. What four form nearly a rectangle? Explain the cut of $\tau$ Ophiuchi. What of the stellar system p Ophiuchi? What is its period? How does its orbit compare with that of $\gamma$ Virginis? Give a full description of this system, its peculiarities, importance, &c. Relate the fable.

Where is the head of the Serpent, and what stars does it contain? Where are $\alpha$, $\delta$ and $\varepsilon$? How is the direction of the tail indicated? What are the names of the principal stars in the Serpent?

Where is the Dolphin situated? What figure is formed by the four principal stars? What star lies south-west of the rhombus? Relate the fable.

Where is Equüleus situated? How may it be known? What is this asterism said to represent?

By whom was Sobieski's Shield instituted? Where is it? How may it be found?

Where is the Solitary Thrush, and by whom was it established?

Where is the constellation of the Fox and Goose situated? What else can you say of it?

Where is Sagitta, or the Arrow? Relate the fable of the Arrow.

## Plate X.

Name the Constellations in Plate X.

What are the principal stars in Sagittarius? Where does it lie? Where is the Bow, and how is it marked? How is the Arrow marked? How does it point? Give the history of this constellation. When does the sun enter this sign?

Name the principal stars in the Scorpion. Where is Antares? What stars are west of it? What of the stars in the extremity of the tail? What is the fabulous history of this sign? When does the sun enter it?

Where is Lupus, and what can be said of it?

Where is the Altar situated?

What is the situation of the Rule and Square? By whom was it instituted?

Where is the constellation of the Telescope?

Where is that of the Southern Crown?

## Plate XI.

Mention the Constellations in Plate XI.

What are the principal stars in Aquarius? Describe the figures formed by these with $\epsilon$ and $\eta$. What stars are in the Urn? Relate the fable. When does the sun enter this sign?

Name the principal stars in Capricornus. Where does this constellation lie? What are the situations of the stars in it? Give the history of this sign. When does the sun enter it?

Where is the Southern Fish? By what star is it distinguished? What does Fomalhaut form with $\beta$ and $\epsilon$?

Where is the Balloon situated, and by whom was it introduced?

Where is the Microscope situated?

What can you say of the constellation of the Crane?

Where is the Phœnix?

Where does the constellation of the Sculptor's Tools lie?

Where is that of the Indian?

What can you say of the six last named constellations?

## Plate XII.

Name the Constellations in Plate XII.

What are the principal stars in Cetus? How may the head and neck be known? How may the other stars be found? What four form a parallelogram? What is the history of this sea-monster?

Where is Eridanus? What are the most important stars? Where may this constellation be traced? How may the principal stars visible in our latitude be found? Relate the fable.

What is the situation of the Hare? By what four stars may it be known? What are the other stars, and where?

Where is Harpa Georgii?

How is the Sceptre of Brandenburg situated? Of what does it consist? By whom was it formed?

Where is the Chemical Apparatus?

Where is the Electrical Machine?

Where is the Graver?

Where is the Clock? Of what are the last six constellations composed?

## Plate XIII.

What Constellations are represented in Plate XIII.

Name the most important stars in the Great Dog. Where is it situated? What of Sirius? Where are $\gamma$ and $\beta$? What of $\delta$, $\varepsilon$ and $\eta$? What do $\zeta$, $\beta$, $\alpha$ and $\varepsilon$ form? Relate the fable.

What are the principal stars of the Ship Argo? What of Canopus? How may the prow of the ship be known? Explain the method of finding the other principal stars. Give the history of this constellation.

Where is the Dove situated?

Where is the Cat?

Where is the Painter's Easel?

Where is the Printing Press?

Where is the Compass?

## Plate XIV.

Name the Constellations in Plate XIV.

What is the extent of the constellation Hydra? How may the head be known? What is $\alpha$ called, and where is it? How is the first coil marked? Describe the course of the Water-Serpent. Relate the fable.

Where is the Cup? How may it be found? What of its principal stars? Give its history.

Where does the Centaur lie? What of it? Give the history.

Where is the Crow situated, and how may it be recognized? What is its history?

Where is the Air-Pump situated, and by whom was it introduced?

Where is Charles' Oak, and by whom was it placed in the heavens?

What can you say of the Cross? What of these two and the constellations farther south? Give the names of the latter.

Describe the two Black Clouds.

Describe the two Southern Clouds.

### Sec. 12.

#### CALENDAR OF THE STARS.

Note.—In studying this calendar the student should have frequent reference to the maps, and to the heavens. The calendar for the middle of the month may be adapted to any other day of the same month by allowing four minutes for each day before or after the fifteenth. Thus, the calendar for January is a representation of the heavens as they appear at half past nine o'clock on the 15th day, and as each star rises four minutes earlier each day than the preceding, they will evidently be in the same situations on the first of the month one hour later, or at half past ten o'clock; and on the 30th of the month at half past eight o'clock in the evening, or an hour earlier.

---

## QUESTIONS TO PART II.

### Sec. 1.

What are the planets? Why are they so called? What of their motions?

How many planets are there? Which of them were known to the ancients? What of the other five? When discovered, and what are their names? What are primary planets? What other bodies are there connected with these? Of what is the solar system composed?

### Sec. 2.

#### THE PTOLEMAIC SYSTEM.

What was the supposition of the ancients in regard to the planetary system? What difficulties did they encounter?

What was the system called, and by whom was it received? What did Pythagoras maintain? How long did this system hold sway?

## Sec. 3.

### THE COPERNICAN SYSTEM.

When was the Copernican System first promulgated? Who was its author? What is the arrangement of the bodies in this system?

What is the earth now proved to be?

What was supposed to be the form of the earth in the earliest ages? What first induced people to consider it a sphere?

What other evidences have we of its spherical form? Is the earth a perfect sphere?

What is the aspect of the heavens with reference to the horizon of a spectator upon the earth's surface? Supposing the earth to be stationary, with what velocity must some of the fixed stars move? What then must be the true cause of the apparent diurnal motion of the heavens?

Describe the apparent motions of the planets. Are these appearances real? How can they be explained?

## Sec. 4.

### DEFINITIONS.

What are Planets? Into what two classes are they distinguished?

What is the centre of motion of the primary planets? How many of this class are there? Give their names and characters.

What are secondary planets? How many are there? About which of the primaries do they revolve?

What is the orbit of a planet? Where is the earth's orbit?

What are Nodes? What are the two Nodes called and how are they marked?

What is meant by the term Aspect? What is Conjunction? What is Opposition?

What are the Syzygies? The Quadratures?

When is a planet's motion said to be direct? When retrograde?

What is a Digit? Define a Disc.

What are Geocentric latitudes and longitudes?

What are Heliocentric latitudes and longitudes?

What is the Apogee? What the Perigee?

What is the Aphelion? What the Perihelion? What are these points sometimes called? What is the Line of Apsides?

What is the Eccentricity of an orbit?

What is an Occultation? What a Transit?

What is an Eclipse of the Sun? What is an Eclipse of the Moon?

What is the Elongation of a Planet?

What is a Diurnal Arc? A Nocturnal Arc?

What are the elements of the Orbit of a Planet?

## Sec. 5.

### KEPLER'S LAWS.

What curves do the planets describe about the sun? At what point is the sun situated? What can you say of the paths of comets?

Define the Ellipse. What is the Transverse Axis? What are the Foci? What is a Radius Vector?

By whom and how was this law discovered? What is meant by a Conic Section? When is it a circle, and when an ellipse? What is the Eccentricity of an Ellipse? What is a Parabola? What is an Hyperbola?

What is Kepler's Second Law? Explain it? When has a planet its greatest velocity? How does the velocity vary?

How may this property be illustrated by experiment?

What is Kepler's Third Law? Give the example.

Does this law extend to the secondary systems?

## Sec. 6.

### THE NEWTONIAN THEORY OF GRAVITATION.

What can you say of Sir Isaac Newton's discovery?

What force causes the moon to revolve around the earth? What is said of the extent of the influence of this force? In what proportion does the force of gravity between two particles diminish? How does it increase?

What can we infer from this law of gravity? Explain.

What is said of the extent of this law? What knowledge may be derived from this fact? What did Bessel determine concerning the stellar system 61 Cygni?

## Sec. 7.

### THE SUN.

What can you say of the sun? To what class of heavenly bodies does it belong? Why does he appear so much brighter

and larger than the fixed stars? What is his distance from the earth? How long would it take a cannon ball to reach the sun? How does he compare with the other fixed stars in that respect?

What is the figure of the sun? His diameter? His bulk? In what time does he revolve about his axis? How is this axis inclined? Towards what points is it directed?

What is the sun supposed by some philosophers to be? What is Sir William Herschel's hypothesis? What causes the dark spots? What the brighter spots? What are these spots called? What has been ascertained from observations of these spots?

What other singular phenomenon accompanies the sun? Describe it. What is it supposed to be? What does Professor Olmsted suggest?

What is the force of gravity at the sun? How far does a body fall during the first second of time? What would the physical power of our men avail them there? What of the sun as an habitation?

What is the proper motion of the sun, and towards what point is it directed? What is the Uranographical effect of this motion?

Relate the fable. What is the astronomical sign of the sun?

## Sec. 8.

### MERCURY.

Which planet is nearest the sun? In what time does it revolve around the sun? In what time about its axis? What does this constitute? Why is this period uncertain?

What is Mercury's distance from the sun? At what rate does it move in its orbit? What is his diameter? What his appearance?

What are Mercury and Venus called? Why? What are the other planets called? Which of the planets can never be in opposition? What is their inferior conjunction? What their superior?

How far can Mercury depart from the sun? What of his phases?

What is a Transit of Mercury? At what seasons can they occur? Mention those which will occur during the remainder of the present century.

What do the phases of this planet prove?

What is its density? Its mass?

What can you say of the seasons of Mercury? What of the intensity of its light? What is the apparent diameter of the

sun as seen from Mercury? What is the variation in the length of its day?

How large does Venus appear from Mercury? How does the earth appear? How the other planets?

How does the weight of a body at Mercury compare with its weight at the earth? How long is the seconds pendulum there? What can you say of the compression of this planet?

What was Mercury considered to be by the mythologists? What is the astronomical sign of this planet?

## Sec. 9.

### VENUS.

What is the distance of Venus from the sun? In what time and at what rate does she revolve around him? What is the time of her diurnal rotation? What is her magnitude?

What is the appearance of Venus, her phases, spots, &c.?

What of Venus' apparent diameter? Explain the drawing.

What can you say of the difference in her seasons?

How far does this planet ever recede from the sun? When is she called the morning star and when the evening star? How long does she continue to be one or the other?

What can you say of the telescopic appearance of Venus?

What of its Transits? At what intervals do they happen, and in what months? Give a list of all the Transits from 1639 to the 22d century.

What can you say of the observations of that of 1769? What result did Encke deduce from them?

What is the intensity of the sun's light at Venus? What is his apparent diameter?

Which is the most brilliant body in the evening sky of Venus? How does our moon compare with Mars there? What of the phases of the earth? What of the eclipses of our moon, and its Transits over the earth's disc?

What of the weight of bodies at Venus?

## Sec. 10.

### THE EARTH.

How far is the earth from the sun? What is its diameter? Its circumference? Its surface? What is its mass? What is its density?

What is the figure of the earth? What was the opinion of

the ancients in regard to this? How is the spherical form proved? How has the flatness of the earth at the poles been ascertained?

What is the centrifugal force at the equator? If the velocity of the earth was 17 times as great as it is, what would bodies weigh at the equator?

How does the compressed form of the earth affect the weight of bodies on different parts of the surface?

What can you say of the fall of a body in the first second?

What of the length of the seconds pendulum?

What are the sensible motions of the earth? Describe the annual revolution. Describe the diurnal rotation and its effects.

What are the insensible motions?

How is the alternation of day and night produced? How may this be illustrated by experiment?

At what places are there but one day and one night? How is it with places within the polar circles? Explain this.

What can you say of the twilight in the polar regions? What of the light of the moon?

Upon what does the variety of the seasons depend? What constitutes a summer season, what a winter, and what a spring or autumn?

What are the seasons in December? What in March and September?

How are the changes of the seasons illustrated by the diagram?

What can you say of the earth's satellite? How does the earth appear as seen from the moon? When we have new moon, what phase does the earth present to the moon?

What is the Atmosphere? How does it affect the rays of light? What would be the appearance of the heavens by day without it? What are produced in it?

What can you say of its density? What of its height? Its weight?

What is the mass of the atmosphere? What would be its height if its density were the same throughout as at the earth's surface? What is its greatest possible height? Why? How does its temperature vary at different heights?

How does the atmosphere affect the apparent positions of the heavenly bodies?

What is the amount of refraction at the horizon? What at 45° of altitude? What in the zenith?

What constitutes wind? How are clouds and rain produced?

What can you say of the position of the axis and of the poles with regard to the earth itself? What of the position of the axis in space? What circle is described by the north pole, and in what period? Give the list of north polar stars. How long has our present pole-star held that rank, and how long will it continue to hold it?

What can you say of the south polar stars?

With what consequence is this change in the position of the axis attended?

What will be the position of the celestial equator 12,000 years hence?

Give an account of the second variation.

What is meant by a perturbation of the motion of a planet?

What is the third variation? When is the earth nearest the sun? When will this happen 58 years hence? When will it happen 10,000 years hence? How will this affect the duration of the seasons? How the temperature? What is the eccentricity of the earth's orbit?

What is the astronomical symbol of the earth?

## Sec. 11.

### SATELLITES OR MOONS.

What can you say of the proximity of the moon? Of what do we know the existence, and of what the absence?

What have the satellites in common with their primaries?

What can you say of the times of rotation of the satellites about their axis? What follows from this? How is this of advantage to them?

What other consequence of the equality of their periods of rotation and revolution can you mention? Define *Libration.*

What is the largest body in the firmament of a satellite? Is it visible from all parts of the secondary?

What can you say of the phases of the primary? Their period? Give a more particular account of these phases as they appear from different parts of the surface of the moon. What can be said of eclipses of the sun as they occur for each satellite? What of the eclipses of the primaries?

Which are best adapted for observations of the heavens, the primaries or the secondaries?

How does the force of gravity at the surfaces of the moons compare with that at the surfaces of the primaries?

What is said of the importance of this element? What is the ratio of the forces of gravity at the sun, the earth and her moon?

## Sec. 12.

### THE MOON.

To what class of bodies does our moon belong? Whence does she receive her light and heat? Around what bodies does she revolve? At what rate does she move around the earth, and at what distance? In what time does she complete this revolution? What is this called? What constitutes a sidereal revolution, and in what time is it performed by the moon?

What is the moon's diameter? How does her bulk compare with that of the earth? What is the direction of the moon's apparent motion, and to what is it owing? In what direction does the moon actually move? How may this be ascertained?

In what time does the moon revolve about her axis? What is the consequence of this? What causes a slight variation in the face which she presents to us? What is the moon's libration in longitude? Its amount? What is her libration in latitude? To what does it amount?

How many days and nights has the moon in one of our lunar months? Of how many of her days does her year consist? What of her seasons?

What can you say of the light which the earth reflects upon the moon?

Give an account of the variation of the phases of the moon.

When does the disappearance take place? What is this called? What phase does she present when she is in opposition? How does she appear when in her quadratures? In what is she then said to be?

On which side is the illuminated part from the change to the full?

What is an eclipse of the sun, and what an eclipse of the moon? When can the former occur? When the latter? Why do eclipses not occur at every new and full moon? What is the greatest number that can occur in a year? What the least?

What can you say of the harvest moon?

What of the full moon as seen through a telescope? When are the mountains best observed?

How must the heavens appear at our moon? Give an account of the advantages of clear sky, &c., possessed by the moon.

How large does the sun appear when seen from the moon? How large does the earth appear?

What is the length of the day at the pole of the moon? How far below the horizon can the sun descend? How and where would it be possible for a person to attain perpetual sunshine?

What is the length of the lunar year? What of the difference of the seasons? Why?

When the moon is totally eclipsed at the earth, what occurs at the moon? What phenomena occur at the moon when at the earth the following happen, viz: a partial eclipse of the moon, a passage of the penumbra of the earth over the moon, a total eclipse of the sun, an annular or partial eclipse of the sun?

What can you say of the occultations of the fixed stars by the earth?

How does the earth constitute a time-piece for the moon?

Give a general description of the character of the surface of the moon. How high are some of the mountains? What can you say of the mountain ranges?

What of the circular ranges of mountains? What do they resemble? What are walled planes?

Which is the deepest cavern in the moon? Describe it.

Describe the crater-formed elevations. Are the volcanoes believed to be in action or extinct? What is supposed to be the cause of their present inactivity?

Describe the central mountains.

Describe the spot called Tycho. Why are the spots called seas, lakes, gulfs, &c.? What names have been given to many of these objects?

Mention the heights of some of the mountains.

What is the astronomical sign of the moon?

## Sec. 13.

### MARS.

How may Mars be known in the heavens? Whence does this proceed?

How far is Mars from the sun? At what rate does he move, and in what time does he make a revolution around the sun? What is his diameter? What his form? How does his size at the opposition compare with that at the conjunction? Why? What of the light and heat at Mars?

How does Mars appear when viewed through a telescope? What is the inclination of the plane of his orbit? What is that of his axis? What are his greatest and least apparent diameters? What are his volume, his density, his mass? What would a body weighing a pound here, weigh at Mars?

What can you say of the spots on the surface of this planet, and of their cause?

From what is the existence of an atmosphere inferred? Describe the spot at the south pole.

What is the period of rotation of Mars?

How many martial days are there in his year? What are the lengths of the seasons respectively?

What occasions this great inequality in the lengths of the seasons? Into what zones may the surface of Mars be divided? What can you say of the inequality of the days at Mars?

Which of the planets are *Inferior* with respect to Mars? Describe the appearance of the heavens from Mars.

How large does the sun appear there?

Towards what points are his poles directed?

What is the astronomical sign of Mars?

## Sec. 14.

### VESTA.

By whom and when was Vesta discovered? What is its appearance? Its diameter? What is its distance from the sun? Its period of revolution? What is the inclination of her orbit? What else can you say of this planet? What is its symbol?

Note. — The above questions may be applied to Juno, Ceres and Pallas, Sections 15, 16 and 17.

## Sec. 18.

### GENERAL REMARKS CONCERNING THE ASTEROIDS.

What was Dr. Olbers' idea with respect to the origin of Ceres, and to what did it lead?

What remarkable conjecture had Professor Bode made previously to the discovery of Ceres? On what ground?

What knowledge have we respecting the magnitudes, rotations and positions of the axes of the Asteroids? Which is the largest? What is the surface of Vesta?

To what is our information concerning these bodies confined? Which of the orbits are most eccentric?

What are their inclinations? What name has been given to them in consequence of this?

What are their mean distances?

What are their periods of revolution? What can you say of the distances and periods of Ceres and Pallas? Do they move in the same path? How do their orbits differ?

Describe the appearance of the heavens as seen from the Asteroids.

## Sec. 19.

### JUPITER.

What is the magnitude of Jupiter? In what time does it make a revolution, and what is his distance from the sun? What is his rate of travelling?

In what time does he revolve about his axis? How does his rotary velocity compare with that of the earth? Of what does his year consist? How does his equatorial compare with his polar diameter? Of what is this a consequence?

What can you say of the density and mass of Jupiter?

What is the force of gravity at his surface?

Is the weight of bodies the same on all parts of Jupiter's surface? What is the cause of this difference?

What can you say of the centrifugal force at the equator of Jupiter? What is the length of the seconds pendulum at his equator? At his poles?

What can you say of the difference of seasons at Jupiter? Why is it so slight?

What is the intensity of light and heat there? How large does the sun appear there?

With what velocity do the stars appear to move there?

What can you say of the view of Saturn from Jupiter? How large does it appear? What of the transits of the inferior planets?

Describe the belts of Jupiter. How many are sometimes seen? What are they supposed to be?

Give an account of the spots upon Jupiter's surface.

What can you say of the bright spots sometimes seen?

How many moons has Jupiter? Who discovered them? What are their periods of revolution? What can you say of the eclipses of these moons? Of what practical use are they to us? What important law of light have they been the means of demonstrating?

What is the greatest ornament of Jupiter's sky? What are their apparent diameters? What else may be said of them?

What portion of the primary can be seen from one of these moons?

In what direction do the satellites revolve? In what planes? How do they appear to move when viewed from the earth?

How often are the first three satellites eclipsed? How often is the fourth? At what intervals does the first suffer a total eclipse?

What can you say of the amount of Jupiter's moonlight?

What portions of his surface have no moonlight?

What of the retrograde motion of Jupiter?

What heavenly bodies may be observed at Jupiter?

Relate the fabulous history.

## Sec. 20.

### SATURN.

Which is the tenth planet from the sun? What is his mean distance? His diameter? His velocity? His period of revolution? His time of rotation? The inclination of his orbit? How is his axis inclined to the plane of his orbit?

What is the apparent diameter of Saturn? Describe the rings.

In what plane do they lie? By what are they separated? What is their thickness?

Describe Saturn as represented in the frontispiece. From what is it evident that the ring is a solid opaque substance? What is the position of the axis?

What can you say of the parallelism of the axis? In what time do the rings rotate? In what plane?

How is their plane inclined to the ecliptic? What are the nodes of the ring? Where are they? Under what form do the rings appear to us? Give an account of the variations in the form of the rings, their disappearances. How often does the ring disappear from our view? How does the ring vary after the planet has passed one of the nodes? What is its form when the planet is 90° from the node? What is the ratio of the two diameters then? Explain the figure.

Are the rings of uniform thickness and density throughout? What is the position of the centre of the ring?

Describe the spectacle presented by the rings of Saturn to the inhabitants of that planet. How do they appear to those on the equator? How to the inhabitants of the polar regions?

How are the rings illuminated during one half of Saturn's year? What is the condition of the portion of the surface of the planet towards the sun? What is that of the portion lying under the dark side of the rings?

Of how many days does Saturn's year consist? What are the durations of its seasons? What is the intensity of light there? How large does the sun appear there?

What is the force of gravity at the poles of Saturn? What is the length of the seconds pendulum there? What is it at the equator?

What can you say of the apparent diurnal motion, &c., of the stars for Saturn?

How many satellites has Saturn? What can you say of their magnitudes?

What is the peculiarity of the phases of these moons, and what is the cause of it?

At what intervals does the first satellite pass the meridian of a given place on the surface of Saturn? Explain it.

At what seasons can the eclipses of these moons occur? During what length of time will the innermost satellite be eclipsed at every full moon? How is it with the others? How often do these satellites cause eclipses of the sun?

What can you say of the appearance of these moons from the earth? What of the most distant? In what time is it supposed to make a rotation about its axis? What of the first three? How were they seen by Sir William Herschel?

What can you say of the orbits of these satellites?

## Sec. 21.

### URANUS.

By whom and when was Uranus discovered? What name did he give it? By what other name was it called by foreigners? What was the reason for calling it Uranus?

Describe this planet?

What is its mean distance from the sun? His diameter? His bulk? What is the inclination of his orbit?

What is the period of his revolution around the sun, and what is his velocity? What is his time of rotation?

How much light does this planet receive from the sun?

How large is the sun as seen from Uranus?

What can you say of the situation of Uranus in regard to observations of the other bodies of the system? What bodies are visible in his heavens at midnight?

Is this planet much nearer any of the fixed stars than we are?

What can you say of the annual parallax of the fixed stars at Uranus?

What is the greatest peculiarity of the Uranian system?

What can you say of the phases of these moons?

What of the eclipses of these moons and of the sun? During what length of time will there be no eclipses?

What is the density of Uranus? What of the weight of bodies at its surface?

What constitutes our whole knowledge of these bodies?

## Sec. 22.

### COMETS.

What other class of bodies belong to our system besides the primary and secondary planets?

What is the number of comets on record? What of the first 450 of these? What of the rest? How many comets are estimated to have visited our system since the creation? What estimate may be formed of the number, including those too far off to be seen at the earth?

Of what three principal parts is a comet composed? What can you say of the head? Mention the diameters of the heads of some comets.

What of the nebulous envelope?

What is the tail? Is it ever wanting? What is then the shape of the nebulous envelope? What can you say of the curved tails which some comets have?

Have comets ever more than one tail? What of the comet of 1823? That of 1744? That of 1811?

What can you say of the comet of 371 years B. C.? That of 43 years B. C.? What was it supposed to be? What does Seneca say of the comet of A. D. 60? What of the comets of 1402? How long was the tail of the comet of 1456? Describe the tails of the comets of 1618, 1680 and 1689. Describe the comet of 1744. What was the length of the tail of the comet of 1843?

Mention the real lengths of the tails of some comets?

To what do the tails of comets owe their origin? What is their general character?

Do comets shine by their own light? How is the nebulous envelope supposed to be formed? What is probably their condition when farthest from the sun?

What is the effect of the heat of the sun as the comet approaches it? What is said of the nature of these substances? What is the force that governs the distance of the particles? To what force is the formation of the tails attributed? Explain it.

In what case is the tail long and narrow? When the comet's head and the cometary repulsion are greater, what is the form of the tail?

What becomes of the particles that form the tails of comets?

What was the opinion of the ancients concerning comets?

What was the effect of the appearance of Halley's comet, in 1456, on the minds of the people?

Is it probable that comets have any effect upon the seasons?

What other source of apprehension is there? Is there any probability of the head of a comet striking the earth?

If such a shock should occur, what might be the consequences? What is said of the mass or weight of many comets?

How does the comet of 1770 confirm this?

Are the elements of the orbit of a comet the same as those of the planetary orbits? Which of these cannot generally be determined for a comet?

What is the average of all the inclinations of the planes in which the comets move?

What is the shape of their orbits?

In what curves do all comets probably move? Why? Why do astronomers sometimes derive hyperbolic orbits?

What was the orbit of the comet of 1843, as computed by observations made at the High School Observatory?

What is the estimated average period of revolution of comets? What number of comets have been observed and their elements computed?

What is the period of Halley's comet? What is the inclination of its orbit? What is its least, and what its greatest distance? What is its eccentricity? Why is it named after Halley? How long does it remain within the orbit of the earth when at its perihelion? How near may it approach to the earth?

Mention the dates of the supposed appearances of this comet, and the circumstances attending some of these appearances.

When was its first certain appearance? Describe it. When was its next? When its third? What can you say of its fourth, in 1682?

What period did Halley assign to it? When did he predict its return? When did it return? By what was it retarded? What is said of its return in 1835, and of our knowledge of its period?

When was Olber's comet discovered? What is its period? Its inclination? Its least distance? Its greatest? Its eccentricity? When will it return to its perihelion?

What is Encke's comet sometimes called? What is its period? Its inclination? Its eccentricity? What are its least and greatest distances?

By whom and when was it discovered? Who first ascertained its period? By whom had it been seen? What of its returns from 1825 to 1842? How did it appear in 1838?

What did it furnish Encke the means of determining? How?

What resistance does this comet encounter while it is within the orbit of Venus?

How does this affect its period? How its mean distance?

What theory does Encke resort to for a cause for these changes?

What are the grounds for adopting this theory?

Give a more particular account of this theory?

When will the next returns of Encke's comet take place?

Describe Gambart's comet. What are its period, inclination, &c.?

When was this comet last seen? Why was it not visible in 1839?

When is it expected to be visible again?

What is said of the comets of 975, 1264 and 1556?

What of that of 1680?

What of that of 1770? How did La Place account for this?

What is said of the great comet of 1843 and its probable period?

Describe the third comet of 1843. What is its period according to various authorities? What is its inclination? Its eccentricity?

What is said of the influence of Jupiter on this comet?

Between what does this seem to form a connecting link?

What is remarked of the position of its orbit in the heavens?

## Sec. 23.

### ECLIPSES OF THE MOON.

What kind of shadows must the earth and moon carry with them around the sun? Why? What constitutes a lunar eclipse? At what times only can they happen? Why do they not happen every full moon?

What constitutes a partial eclipse? When is the eclipse said to be total? When central?

Where does the shadow of the earth terminate? What is its breadth at the point where the moon passes through it?

What are digits? What is meant by the quantity of an eclipse?

On what does the duration of a lunar eclipse depend? What is the longest duration of a partial eclipse? Of a total eclipse?

Explain the figure. What is the umbra? What is the penumbra?

When does the moon begin to lose sight of the sun? When does the eclipse begin as seen from the earth? When does it end?

What renders it difficult to distinguish the line of separation between the umbra and penumbra? Are these eclipses of much importance?

## ECLIPSES OF THE SUN.

What causes an eclipse of the sun? When can these eclipses occur? Why do they not happen every new moon?

Explain the figure.

At what places is the sun centrally eclipsed? At what places is the eclipse total? At what places is it partial? Upon what does the magnitude of the partial eclipse at any place depend?

What is an annular eclipse?

If, at the time of conjunction, the moon is so far from its node that the shadow does not touch the earth, what takes place?

What is the greatest breadth of the path of the shadow of the moon over the surface of the earth? When does this occur? Of what kind will that eclipse be which happens when the moon is in its apogee and the earth in its perihelion? What is the greatest breadth of the path traversed by the penumbra when it falls perpendicularly on the surface of the earth? Is an eclipse of the sun visible to all the inhabitants of the earth? Do all see it alike? What is the greatest breadth of that part of the surface at which the eclipse is annular?

What is the longest time that an eclipse can continue total? How long annular?

What are the limits for eclipses of the sun? What are they for lunar eclipses?

How many eclipses can there be in a year? How few? Of which kind are these two? When there are seven, how many are of the sun?

How do the eclipses occur in a series of 223 lunar months? Explain this. How many eclipses are there in this period? How many of these are of the sun?

What was this period called by the Chaldeans?

## Sec. 24.

### TIDES.

What is the tide? What causes it? What are the rising and falling tides denominated? What is the average interval between two successive high or low tides?

What are spring tides? What are neap tides? When do they occur? At what seasons of the year are the tides higher than usual?

Describe the motions of the waters of the sea, rivers, &c., during the rising and falling of the tides.

What variation in the time of high water occurs each day?

When is the retardation in the time of high water least, and when greatest? What other circumstances have an effect on the retardation of the tides? What of the tides when the moon has a north declination? What when her declination is south?

What shape would the waters in the ocean assume, were there no influence from either sun or moon, and the earth at rest? What would be the case if the earth and moon were without motion?

How does the moon cause the particles of water immediately under her to rise? How those diametrically opposite?

How much greater is the moon's attraction for the water immediately under her than for the centre?

If the earth were entirely covered by the sea, what form would the waters attracted by the moon assume? Which is the greater, the elevation or the depression? How do the effects of the sun's attraction compare with those of the moon's?

Does the summit of the waters point towards the moon? Why? How far from the meridian under the moon is it generally high water in the open sea? On which side of this meridian is the tide flowing? How is it on the east side? How is it 90° distant? How often must these tides happen? Why?

What is the ratio of the forces with which the sun and moon move the waters? How do the spring compare with the neap tides? What constitutes the former? What the latter?

Why do the tides rise higher at some seasons than at others?

What is the interval of time between the moon's passing the meridian and high water?

Do the tides always answer to the same distance of the moon from the meridian, at the same place? How are they affected?

When will the greatest spring tide happen? When the least? At what seasons of the year do the greatest tides occur?

Do the highest tides occur just at the time of new or full moon? How long after?

How do the evening tides compare with the morning tides at places remote from the equator? How is this explained? When is this inequality greatest? To what does it amount at the poles?

Where do the tides rise highest? How is this accounted for? What is the general elevation of spring tides in the open sea? What is that of neap tides? How high do the spring tides rise at London, the mouth of the Indus, St. Maloes, Cumberland?

Is it high water at all places when the moon is at the same distance from the meridian? What impediments are there to the course of the waters?

Why have lakes no tides? What is said of those of the Mediterranean and Baltic Seas?

What are Co-tidal Lines?

What is meant by the Unit of Altitude of a place? What are those of Cumberland, Boston, New Haven, New York, Charleston?

What is meant by the establishment of a port?

To what is the great height of the tides in the Bay of Fundy attributed?

What is said of atmospheric tides?

---

# QUESTIONS ON THE MAPS.

## Plates I. & II.

Note. — These two plates contain the principal stars in each constellation, connected together by lines which form a variety of geometrical figures. The inner circle is divided into degrees of Right Ascension, and the outer into twelve parts, corresponding to the months of the year. The latter division is intended to show what stars pass the meridian at nine o'clock in the evening, at any season of the year. Thus, on the first of January all the stars in R. A. 56° will be on the meridian at nine o'clock; those having a few degrees more R. A. will be found a little east, and those having a few degrees less, a little west of the meridian. And on the 10th of January, all the stars in R. A. 66° will be on

the meridian at nine o'clock in the evening. To a person in north latitude, the stars surrounding the north pole within a distance from it not exceeding the latitude of the place, will be always visible; and those within the same distance of the south pole will always be invisible to him.

It must be remembered that Right Ascension is reckoned from west to east, in ascertaining the directions of the stars on the map from one another and from the meridian.

---

What constellations are on the meridian and above the horizon of Philadelphia, (latitude 40° N.), at nine o'clock in the evening, on the 1st of January? On the 26th of February? On the 5th of May? On the 15th of August? On the 20th of November?

What constellations are always above the horizon of Philadelphia? What are always below it? What stars lie within 10° of the equator on the north? What on the south? What stars lie on the ecliptic? Through what constellations of the northern hemisphere does the ecliptic pass? Through what southern constellations does it pass?

## Plate III.

Name the constellations on this plate. How are the Grey-Hounds bounded? What part of the Great Bear lies north of them? What is the extent of this constellation in Right Ascension? What in Declination? What are the R. A. and Dec. of $\alpha$ or Cor Caroli?

By what constellations is the Little Bear bounded? What is the brightest star in this constellation? What figure do the principal stars form? Draw it, and give the names of the stars composing it.

How is the Dragon bounded? What are the R. A. and Dec. of the head? Mention the principal stars in the head. What part of the Dragon lies between the Pole Star and the Lyre? Where are the other coils? Where is the tail?

Where is the Quadrant? How is it bounded?

How is the Swan bounded? Give the situations of $\alpha$, $\beta$, $\gamma$, $\delta$, and $\varepsilon$, and their Right Ascensions and Declinations. What figure do these five stars form? Which two point towards the Pole Star? What is the extent of this constellation in R. A.? What in Dec.?

What small constellations lie east of the Swan? How are they bounded on the north? How on the south? What is east of the Glory of Frederic? What west?

How is Cepheus bounded? What figure is formed by $\beta$, $\alpha$ and

$\eta$? What by $\alpha$, $\eta$ and $\chi$? In what Declination are $\alpha$ and $\eta$? What stars are in the Crown? What three small stars are on a line with $\beta$? What four small stars form a rhombus between $\beta$ and the Little Bear?

## Plate IV.

Name the constellations on this plate.

How is Cassiopeia bounded? What are the five principal stars and what figure do they form? Which is nearest the pole? What is the R. A. of $\beta$? What three stars lie near the parallel of 60°? How is the head marked?

What two small constellations lie between Cassiopeia and the pole? Give their boundaries.

Give the boundaries of Perseus. What is its extent in R. A. and Dec.? What are the principal stars in this constellation, and how are they situated? Where is Medusa's Head? What stars are in the knees? What in the hilt of the sword?

How is the Cameleopard bounded? Of what kind of stars is it composed? What is its extent?

How is the Lynx situated, and of what does it consist? What small constellation lies south of it?

How is the constellation of the Great Bear bounded? What figure is formed by the seven principal stars? Draw this figure. What star is at the end of the tail? What star is next to it? What two stars point nearly towards the pole? Which is nearest the pole? What two stars of the third magnitude are on a line with $\beta$ and $\delta$? Give the situations of the small stars in the head and the two hinder feet of the bear. Give the R. A. and Dec. of $\alpha$, $\gamma$ and $\varepsilon$.

What small constellation lies immediately south of the Great Bear? How is it bounded, and of what is it composed?

## Plate V.

What are the principal constellations on this plate?

What are the boundaries of Pegasus? What three bright stars form nearly a square with $\alpha$ of Andromeda? In what R. A. are $\alpha$ and $\beta$? In what Dec. are $\alpha$ and $\gamma$? Mention some of the stars in the head and neck. Where is $\varepsilon$, and what are its R. A. and Dec.? What stars are near $\beta$?

Where are the Fishes situated? How are they connected? What is the extent of this constellation?

How is Andromeda bounded? What are the R. A. and Dec. of $\alpha$ in the head? What three bright stars are in a right line?

What smaller stars lie in a line nearly parallel to and above this? What star forms, with $\alpha$ and $\beta$, a right-angled triangle?

How is the Ram bounded? What are the stars in the head? Give the R. A. and Dec. of $\alpha$ and $\beta$. Where is $\delta$?

What small constellation lies between the Ram and Andromeda? What one east of the Triangles? What figure is formed by the stars $a$, $b$ and $c$ of the Triangles.

## Plate VI.

Name the constellations on this plate.

How is that of the Bull bounded? What is its extent? What are the R. A. and Dec. of $\alpha$, or Aldebaran? Mention the principal stars in the head. What is this cluster called? (See Plate XVI.) By what stars are the horns marked? In what direction are they from the Hyades? In what R. A. and Dec. are the Pleiades, or Seven Stars? What four small stars south-west of these?

What beautiful constellation lies south-east of the Bull? How is Orion bounded? What is its extent? In what R. A. and Dec. are $\alpha$, or Betelgeux, and $\beta$, or Rigel? What three stars mark the belt, and how are they situated with respect to $\alpha$ and $\beta$? What stars are in the sword? What one is just below the sword? Where is $\gamma$? How is the shield marked? Draw a figure of this constellation.

Give the boundaries and extent of the Wagoner. What are the R. A. and Dec. of $\alpha$, or Capella? What star lies nearly on the same parallel 10° east of Capella? How is the head marked? Mention some of the stars in the southern part of the Wagoner

How are the Twins bounded? In what part are $\alpha$ and $\beta$, or Castor and Pollux? Which is farthest north? What are the other five principal stars, and how are they situated? Near what meridian is $\alpha$? By what parallel is it separated from $\beta$?

How is the Little Dog bounded? Give the R. A. and Dec. of $\alpha$, or Procyon. What is the other principal star? In what direction is it from Procyon? In what from Castor?

What constellation lies south of the Twins and the Little Dog, and east of Orion? What is its extent in R. A.?

How is the Crab situated? What are the R. A. and Dec. of the cluster of stars called Præsepe, near $\gamma$? Where are $\alpha$ and $\beta$?

## Plate VII.

Name the principal constellations on this plate.

What are the boundaries of Boötes? What is the situation

of $\alpha$, or Arcturus? What are its R. A. and Dec.? What two stars, the one in the leg and the other in the girdle, form an isosceles triangle with Arcturus? What stars are above these two and nearly in a line with them? Draw a figure representing the relative positions and distances of the nine principal stars. How many degrees apart are $\gamma$ and $\vartheta$? What stars are in the right or eastern leg? What in the western? What in the club? What constellation lies east of the club?

How is the Northern Crown bounded? Draw a figure representing the principal stars. What do $\varepsilon$, $\delta$, $\gamma$, $\alpha$, $\beta$ and $\vartheta$ form? Of what magnitude is $\alpha$, and what are its R. A. and Dec.?

What are the boundaries of the constellation Hercules? What is its extent in R. A. and Dec.? Where is $\alpha$, or Ras Algethi situated? In what R. A. and Dec. is it? What two stars above it have nearly the same R. A.? What is the distance between $\alpha$ and $\delta$? Between $\alpha$ and $\pi$? What two stars are near the meridian of 250°? Between what parallels are they? What two stars are near the parallel of 20°, and between what meridians are they? Where is the Cerberus, and what are some of the stars in it?

How is the Polish Bull bounded? What are the principal stars, and where are they situated?

How is the Lyre bounded? What are the R. A. and Dec. of $\alpha$, or Vega? What two small pairs of stars make, with it, an equilateral triangle? Which of these is farthest north? Where are $\beta$ and $\gamma$? What double star is near the centre of the Lyre?

## Plate VIII.

How is the Great Lion bounded? Where is $\alpha$, or Regulus? What star lies about 5° north of it? What star is 5° north-east of $\eta$? What figure is formed by these three stars with $\zeta$, $\mu$ and $\varepsilon$? What star is in R. A. 166° and Dec. 16° north? What one is 5° due north of this? What are the R. A. and Dec. of $\beta$, or Denebola, in the tail? Mention some of the most southern stars in this constellation.

What small constellation lies south of the fore-legs, and west of the hind-legs, of the Lion?

How is the constellation of the Virgin bounded? How is it divided by the equator? What are the principal stars north of the equator? What south? What stars lie on or near the equator? On what parallel is $\alpha$, or Spica, situated? What is its R. A.? What figure does it form with $\beta$ of the Lion, and $\alpha$ of Boötes? What two stars of the third magnitude are within this triangle? What stars are in the southern wing? What in the head? What in the feet?

How is Berenice's Hair bounded? What are the magnitudes of the stars of which it is composed?

## Plate IX.

How is the constellation of the Scales bounded? What are the magnitudes and situations of the two principal stars? Where are $\delta$ and $\epsilon$?

What small constellation lies south of the Scales? What four stars in it form a rectangle? Which is the brightest?

What are the boundaries of the Serpent-bearer? Where is $\alpha$, or Ras Alhague, situated? What two stars are below $\alpha$, in the shoulders? Where are $\eta$ and $\zeta$? Name some of the other principal stars.

Where is the head of the Serpent? What stars are in and near the head? Give the R. A. and Dec. of $\alpha$? What is the extent of the Serpent in R. A. and Dec.? What is the R. A. and Dec. of the extremity of the tail?

Where is Sobieski's Shield?

How is Antinoüs bounded? Name the principal stars, and their magnitudes. How are $\kappa$ and $\iota$ situated with respect to each other?

Give the boundaries of the Eagle. Between what two stars is $\alpha$, or Altair, situated? On what parallel is $\gamma$? What two stars lie north-west of Altair?

How is the Dolphin bounded? What figure is formed by the stars in the head? What star lies on the parallel with $\gamma$ in the Eagle? Of what magnitudes are these five stars? In what R. A. and Dec. is $\gamma$?

How are the Fox, the Goose and the Arrow bounded? What are the principal stars? Their magnitudes? Between what parallels do they lie chiefly?

In what direction is Equüleus from the Dolphin? What do the stars $\alpha$, $\beta$ and $\delta$ form?

## Plate X.

Name the constellations on this plate.

How is the Scorpion bounded? What is its extent in R. A. and Dec.? Draw a figure representing the principal stars in the body, and those in the tail. Where is $\alpha$, or Antares, situated? Where is $\beta$? What two stars lie nearly in a line with these? What three stars of the third magnitude lie in the end of the tail? Near what meridian are they? What stars are on the meridian of 250°?

In what direction is the Wolf from the Scorpion? Mention some of the principal stars in the Wolf? What are their magnitudes generally?

What small constellation lies east of the Wolf?

What one east of that and south of the Scorpion's tail? Near what meridian are the two principal stars? On what parallel is $\alpha$?

Where is the Telescope situated?

How is the Southern Crown bounded? Of what magnitude are the stars composing it? What figure do they form?

What are the boundaries of the Archer? What four stars mark the bow? What three mark the arrow? Which way does the arrow point? What stars are in the head? Give the R. A. and Dec. of $\sigma$. Of $\mu$.

## Plate XI.

Name the constellations on this plate.

What are the boundaries of the Goat, or Capricornus? What is its extent in R. A.? What are the R. A. and Dec. of the star $\beta$? What double stars mark the two horns? Where is $\delta$? What four stars in the tail form a parallelogram?

What two small constellations lie south of the Goat? Which of these is farthest east?

What constellations lie north of the Water-bearer? What south? What east, and what west? What is its extent in R. A. and Dec.? What stars mark the shoulders? Of what magnitude are they? Mention some of the stars in the Urn and in the stream issuing from it. What small stars mark the western limit of this constellation? What are the R. A. and Dec. of $\delta$?

What are the boundaries of the Southern Fish? In what R. A. and Dec. is $\alpha$, or Fomalhaut, situated? What is its magnitude? What two stars of the third magnitude are there, and how are they situated with respect to Fomalhaut?

What small constellation lies south of the Southern Fish? What are the principal stars in the Crane? Near what parallel are $\alpha$ and $\beta$?

How is the Sculptor's Shop bounded?

What small constellation lies south of the Sculptor's Shop, and east of the Crane?

## Plate XII.

Name the principal constellations on this plate.

How is the Whale bounded? What is its extent? Give t' ae

R. A. and Dec. of $\alpha$, $\beta$ and $o$. What four stars of the fourth magnitude form a trapezium on the breast of the Whale? What four of the third magnitude between $o$ and $\beta$? What two between $\alpha$ and $o$?

What two small constellations lie south of the Whale? What is the principal star in the Chemical Apparatus, and how is it situated?

Give the boundaries of the River Po. What are the principal stars in the northern part?

Where is the Time-piece situated? Where is the Graver?

What small constellation lies north of the River Po, and east of the Whale?

Where is the Sceptre, and of what does it consist? How are they situated?

How is the Hare bounded? What are the principal stars in it? What are the R. A. and Dec. of $\alpha$? How are the ears marked?

## Plate XIII.

Name the constellations on this plate.

What are the boundaries of the Dove? What are the R. A. and Dec. of $\alpha$? What three stars are in R. A. 86°? What double star is in the head?

What constellation lies south of the Dove?

How is the Great Dog bounded? Name the most conspicuous stars. What are the R. A. and Dec. of $\alpha$, or Sirius? In what direction is this constellation from Orion? Draw a figure representing the eight principal stars? What two of these are on the meridian of 94°?

What part of the Ship Argo is represented on this map? How is it bounded on the north, east and west? What three stars are on the meridian of 120°? In what R. A. and Dec. are $\alpha$ and $\beta$? What stars lie between the parallels of 20° and 30°?

Where is the Printing Press situated?

What are the boundaries of the Compass?

Between what constellations is that of the Cat situated?

## Plate XIV.

Name the constellations on this plate.

W What is the extent of the Water Serpent in R. A.? What tai onstellations bound it on the north? What on the south? In mer hat R. A. and Dec. is $\alpha$, or Cor Hydræ? What are the stars in

the head? Under what constellation do they lie? Between what parallels does the eastern part, or the tail of the Hydra, chiefly lie?

How is the Air Pump bounded?

Where is Charles' Oak?

How is the Cup bounded? Give the names and magnitudes of some of the principal stars.

What constellation lies east of the Cup? What bounds the Crow on the north and east? Give the names and situations of the three principal stars.

How is the Centaur situated? What are the principal stars between the parallels of 30° and 40°? What star is in R. A. 180°, Dec. 50° S.?

THE END.

3477-2

LIBRARY OF CONGRESS
0 003 532 885 3